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Annual Report

Central States Forest Experiment Station

U. S. Department of Agriculture Forest Service

Central States Forest Experiment Station, U. S. Dept. of Agriculture
Forest Service, 111 Old Federal Building, Columbus 15, Ohio
W. G. McGinnies, Director

(Several of the photos contained in this report were contributed by
Southern Illinois University)

1957 ANNUAL REPORT

Interest in forestry is growing in the Central States just as it is in all parts of the country. And with this growth demands increase for more information on how to do a better job of growing trees. All problems cannot be attacked at the same time and many problems take years to solve. So, one of our never-ending jobs is to pick out the most important problems for study and review the work underway. Soon, the task of maintaining active studies takes a big share of our time. This has been the case during the past year.

Our job is to study trees from seed through mature sawtimber, and wood from logs through finished products. Our work ranges from basic research conducted in the laboratory through field studies to manufacturing finished products. We also study markets for forest products and the industries that use these raw materials. Enemies of our forest are in our sights too, as fire, insects, and disease problems are receiving attention.

The population of the Central States region is growing fast. Industrial growth has been even more spectacular. With this growth new problems spring-up and old ones take on new importance. New and increased demands are being made on our forest land. Aside from greater demands for timber, other "products" of the forest are becoming more important--water and recreation, for example.

The quality and quantity of water that comes from our forested watersheds are affected by how we treat these watersheds. So more and more our forest management must be tempered by its effect upon water supplies. And as more people find more leisure time, forests will be looked upon increasingly as recreational facilities. How can all these demands upon the forest be met and reconciled? It's our job to help find out, but our work along these lines is really just beginning.

In this report we have covered in some detail most of our long-term projects and studies as well as our important new work. Much of the material discussed here is presented more fully in our publications for 1957, which are listed and described beginning on page 66.

W. G. MCGINNIES, Director

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Forest Management

Two-thirds of the Central Hardwood forest is made up of trees smaller than sawtimber size. Many of the stands are understocked and of poor composition. However, most of these stands are young and relatively accessible, conditions that favor intensive management. In the southern part of the region, forest land occupies from one-third to one-half the land area. The future economy of this section is directly affected by the forest management practices that are applied.

Most of the Division's effort is devoted to improving hardwood forests. Research results definitely show that these forests will produce good yields when properly managed.

Much effort is also devoted to artificial regeneration of strip-mined land and old fields. Strip-mine plantings have been successful in the region and studies established more than a decade ago are yielding results that will aid in the forestation of such land today.

GENETICS

The task of meeting future demands for forest products will require the combined best efforts of all forest owners, users, and managers. Recent advances in forestry on all fronts is encouraging but one field in particular brightens the outlook for the future. This is the science of forest genetics. Results in Europe and more recently work in this country with conifers, show great promise of increasing tree growth, quality, and disease and insect resistance. Work in hardwoods has been slow to develop although the potential in quality production is high. Here in the Central States only a few studies have been started. Our work will be expanded when opportunities arise. The Divisions of Forest Diseases and Forest Insects are also conducting studies in this field.

Fiber Length of Cottonwood

Little information is available to define variations in wood structure and wood elements in terms of genetics and environment. The Carbondale Research Center, in cooperation with the Forest Products Laboratory and Southern Illinois University, has begun to study effect of environment and genetics on the length of cottonwood fibers. Four equally spaced increment cores 5.2 mm. in diameter were found to be adequate for sampling fiber length in cottonwood trees.

Holes left by the increment borer heal rapidly and the tree is not seriously injured. Wood samples are removed from the pith to the cambium and the mean fiber length in every fifth ring from the pith is determined.

Among more than 50 cottonwood trees located in Missouri, Illinois, Kentucky, and Indiana, fiber length increased as the numbers of rings from the pith increased. This has been found to be true for other species. Next year enough data will be available to assess the effects of heredity and habitat on fiber length in cottonwood.

Yellow-Poplar Seed-Source

Field plantings of yellow-poplar seedlings from 13 different sources were completed in 1957. This work began in 1952 by collecting seed from nine sources in the Central States and from four widely scattered sources in eastern United States. Seed from six of the local sources was collected three different years to find if seed and seedling quality vary by years, and to test differences in progeny from individual seed-trees within stands. Planting stock for three sources was produced at three nurseries to see if nursery practices affect survival and growth.

These long-term studies have already yielded some useful information for producing planting stock. For some sources more plantable seedlings per pound of seed can be produced by fall stratification and spring sowing than by fall sowing without stratification. But for other sources more seedlings are produced by direct sowing in the fall. Density of sowing in the nursery has a significant effect on diameter of 1-year seedlings but little effect on height growth. The relative height of seedlings in the same seedbed is the best criterion for gauging their growth potential in field plantings.

Seed-Source Tests with Conifers

Provenance tests of shortleaf pine from seven seed sources planted on the Sinkin Experimental Forest in Missouri showed that seed from the northern-most sources was best. After 5 years, survival ranged from 26 percent for a Louisiana source to 69 percent for a New Jersey source. The generally poor survival for the entire study is attributed to a severe drought during the first growing season. Total height ranged from 5.4 feet to 6.6 feet.

A seed-source test of shortleaf pine was started in southern Illinois in 1949. Six sources of seed were used. So far, survival of trees has been good, with little apparent difference among trees of the various sources. If future measurements in both the Missouri

and Illinois studies definitely show a superior source for shortleaf pine, the information would be valuable because it is the most important planted tree in both areas.

Eastern redcedar occurs naturally over a wide range so it is not surprising that a number of races or varieties of this species have developed. Although redcedar is not a major species, it is a good tree to plant on old fields or in forest openings on poor sites. Seedlings were planted from eight sources on old fields to find a superior seed source for southern Illinois. Six years after planting, differences among trees of different seed sources were evident. Survival ranged from 16 to 97 percent, height varied from 3.9 to 6.2 feet, and crown volume varied from 1.1 to 5.9 cubic feet. Differences were also noted in foliage color and type, shape of crown, and susceptibility to cedar-apple rust. For Christmas tree purposes the Wilson County, Tennessee source rated best. It has good survival, height, crown volume, and shape and it remains green during the dormant season.

SILVICS

Site Quality Can Be Estimated from Soil and Topography

In order to manage our forests for maximum production, we must be able to predict timber yield and growth rates for any particular tract of land. In standing timber, productivity can sometimes be measured by comparing the height and age of the trees with standard site index curves and yield tables. However, productivity cannot be measured directly on logged areas or on areas where the trees are very young, too widely scattered, or uneven aged. Nor can site quality be measured directly on non-stocked old fields or brush land. Thus for a large segment of our forest land an indirect method must be used for estimating site quality.

Site quality in southeastern Ohio can already be estimated indirectly for yellow-poplar, white oak, black locust, black walnut, and planted red and white pines by correlating tree growth with easily recognized characteristics of the site: Soil depth, soil texture, topography, and aspect. Soil-site studies are now being made for black oak, chestnut oak, and scarlet oak.

Data and soil samples have been collected on 105 one-fifth acre plots in even-aged, well-stocked, upland oak stands. Field data include a description of the soil profile and topography and identification of soil series and type.

Samples of the three most prominent soil layers were collected for laboratory analysis. The stand age and total height were determined and the understory vegetation tallied.

In a preliminary analysis an attempt was made to correlate site index for black oak with soil types as commonly mapped by the Ohio Soil Survey. For some soil types reliable average site-index values were obtained (table 1). These average values can be used to make a general estimate of growth capacity by specific soil types over large areas such as a state or section of a state, but they cannot be used for a specific area. The variation in site quality within a soil type is often greater than the variation between soil types. This great range in site quality for each soil type is apparently related to variations in A horizon depth, stoniness, subsoil characteristics, and topography--factors that are not considered in soil-type classification.

Table 1.--Average site index for black oak on some common soil types of southeastern Ohio

Soil type	: Number : of : plots	: Range in : site index :	: Average : site index :
Muskingum sandy loams and loams	20	60 - 94	76
Muskingum silt loams	22	48 - 90	72
Wellston loams and silt loams	13	62 - 79	71
Rarden silt loams	11	45 - 75	62
Upshur silt loams	7	54 - 75	65

Does Yellow-Poplar Seed Lie Dormant in Forest Litter?

Results of several recent experimental cuttings in the Central States area have raised this question. A study begun in Indiana and Illinois will provide the answer. If yellow-poplar seed remains viable while stored in the forest floor, management of this species can be simplified. Current seed crops would not necessarily control the time of cutting, the number of seed-trees might be reduced, and seedbed preparation could be undertaken with less risk if the reservoir of dormant seed was adequate. The effect of storage time on seed viability will be established in the new study.

Known quantities of seed have been stored in the forest floor by two different methods. One is broadcast seeding on the litter and the other is putting the seed in fiberglass-screen envelopes which are placed between the litter and the humus. Seed will be removed from storage yearly and the viability tested.

Seedbed Requirements for Yellow-Poplar

With favorable conditions yellow-poplar regenerates abundantly, but it may not survive dense, advanced competition. In Indiana a study was started to find out how much competition natural yellow-poplar seedlings can tolerate. Three levels of release following a harvest cut are being studied. The area studied was an opening created by cutting. During logging one-fourth of the area was disturbed by falling, skidding, and decking. Mineral soil and scarified organic material had ten times more seedlings than undisturbed litter (fig. 1). About 10,000 yellow-poplar seedlings per acre are growing on the area 1 year after logging.

Epicormic Branching on White Oak

Epicormic branches that sprout from dormant buds on the boles of white oaks seriously affect the quality of these trees in heavily stocked Iowa stands. A study of trees in a 95-year-old upland stand shows that even though there is no evidence of cutting epicormic branching is closely associated with crown class. Epicormic branching decreased as dominance increased. Results indicate that from the standpoint of quality growth, dominant trees should be favored when thinning even-aged stands (table 2).

Figure 1.--Scarified seedbed was ten times better than undisturbed litter for yellow-poplar reproduction.



Table 2.--Epicormic branching by crown class

Crown class	Epicormic branches	Faces free of epicormic branches	Height to lowest limb
	Number	Number	Feet
Dominant	2.6	2.7	14.8
Codominant	7.0	1.7	10.0
Intermediate	7.7	1.6	9.9
Suppressed	9.9	.9	7.5

NATURAL REGENERATION

Reproduction Following Cutting in Ohio

A recent study in southeastern Ohio reveals that when light cuts of about one-third of the basal area were made in upland oak-hickory stands most of the reproduction was oaks (table 3). Most of these oaks were individuals established before cutting (fig. 2).

Table 3.--Density of tree reproduction
for three degrees of cutting
(Number per acre)

Species or group	Clear cut	Heavy cut	Light cut
Yellow-poplar	6,340	3,020	1,180
All oaks	2,960	5,140	9,310
Other species	2,270	1,600	2,290
Total	11,570	9,760	12,780

When two-thirds of the basal area was cut, the reproduction consisted of oaks and some yellow-poplar. This type of cut created various-sized openings of unequal distribution and the reproduction was not uniformly distributed. Oaks were more abundant in and near the smaller openings and yellow-poplars were more abundant in openings of 1/4 acre or larger. Such a cut permits the least control over the distribution and abundance of reproduction.

Where all trees taller than 4.5 feet were cut, yellow-poplar made up most of the reproduction. The yellow-poplar consisted of seedlings which became established after the cutting. These seedlings were very abundant and were well distributed over the area.

Figure 2.--
Analyzing
the effect
of a "light"
cut on re-
production.



In all three degrees of cutting, hickories, red maple, sugar maple, black cherry, beech, elm, ash, and other tree reproduction made up about 20 percent of the total tree reproduction and shaded about 25 percent of the area. Hawthorne, hazelnut, huckleberry, blueberry, New Jersey tea, and sumac shaded 2 to 6 percent of the area. Degree of cutting had little effect on the number of these species. After clear cutting, herbaceous plants and vines can be expected to cover 40 to 50 percent of the area. In the partially cut stands these plants covered 25 to 30 percent of the area.

Site Preparation Helps Establish Shortleaf Pine in Kentucky

Successful pine establishment in eastern Kentucky requires a seed source, exposed mineral soil, and freedom from hardwood competition. Studies on the Baldrock Forest are providing some good information on pine management. In good seed years, six shortleaf pine seed-trees per acre produced 116,000 seeds, which seems adequate. However, the seeding habits of shortleaf pine are erratic, and possibly more seed-trees are needed to insure enough seed during poor seed years.

Disking and bulldozing after logging has resulted in an increased number of pine seedlings established the first year after treatment (table 4). Bulldozing appears to be superior to disking because it exposes more mineral soil and eliminates more hardwood competition than disking (fig. 3). Whether this lowers site quality has not yet been determined.

Table 4.--Number of first-year shortleaf pine seedlings by
site treatments, and number of seed trees

Seed-trees per acre	Number of seedlings		
	Logged	Logged and disked	Logged and bulldozed
6	1,950	4,500	9,150
12	4,000	8,800	11,900

Pine Regeneration and Seedling Establishment
Related to Overstory Density

For several years the Columbia Center has recorded seed production and seedling establishment in shortleaf pine stands ranging in density from 50 to 140 square feet basal area.

Although the annual seed crop varied, great differences in seed production and seedling establishment were found each year. Stands thinned to a basal area of 50 square feet per acre had the most seed and seedlings (figs. 4 and 5). As stand density increased, both seed production and seedling establishment decreased. Removing understory hardwoods also favored pine regeneration.

Increasing Aspen in Iowa Stands

Many upland oak-hickory stands in eastern Iowa contain small patches of bigtooth aspen. Frequently the surrounding stands are slow growing and low quality. In a study begun last spring on the Amana Experimental Forest four methods were tried to encourage the spread of bigtooth aspen. The treatments were: (1) Parent aspen group was cut, (2) adjacent oak-hickory timber was cut, (3) adjacent timber was killed by poisoning, and (4) adjacent timber was cut and the area disked. Disking was found to stimulate sprouting. Some sprouts occurred as far as 70 feet from the parent trees.

Figure 3.--Mineral soil exposed by a bulldozer makes a good seedbed for shortleaf pine. Many of the hardwoods in the understory were cut off below the root collar and may not sprout.



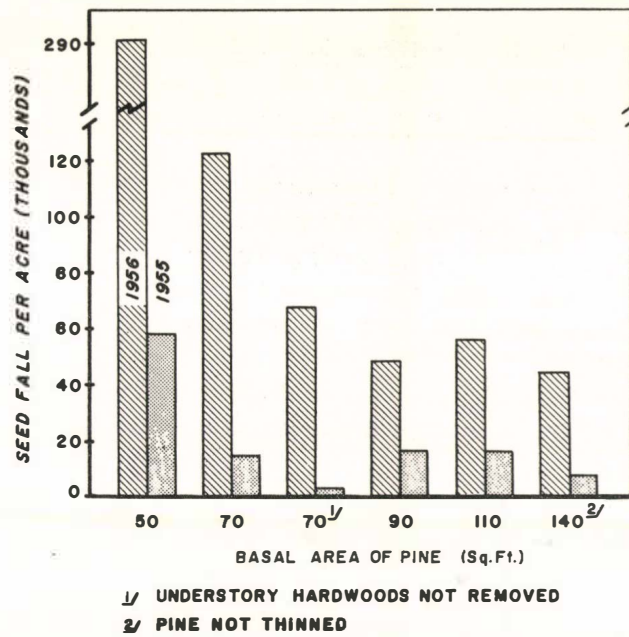


Figure 4.--Seed production for 1955 and 1956 under different stocking levels of shortleaf pine.

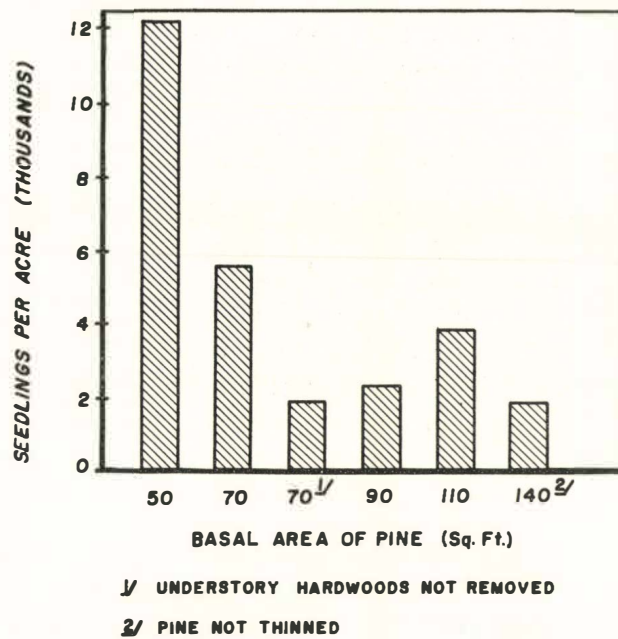


Figure 5.--Seedlings established in 1957 under different stocking levels of shortleaf pine.

STAND IMPROVEMENT METHODS

Herbicides for Killing Oaks

In Missouri, low-quality hardwoods must be killed in plantation release, stand improvement, and pasture or range improvement. Results of a study of 18,000 oak trees indicate that the effectiveness of a herbicide treatment varies with species, size of tree, and season of application. No one treatment was found best for all the oak species tested.

Ammate, 2,4, 5-T, and CMU were applied in various concentrations as basal sprays and in frills. Small trees were easy to kill, but many trees 4 inches in diameter and larger were alive 3 years after treatment regardless of the chemicals used.

The extreme variability of the results may help explain inconsistencies sometimes experienced with herbicides. For example, a 12 1/2-pound AHG (acid equivalent per hundred gallons) solution of 2,4,5-T in fuel oil applied in low frills during November resulted in 93-percent kill of post oak. But treatment of the same species in February killed only 14 percent of the trees. On black-jack oak, this solution was effective only when applied as a relatively costly basal spray.

Even with careful work, 100-percent kill of oaks will seldom result from one herbicide application. The more practical approach probably will be to use a cheap, reasonably effective treatment, and retreat resistant trees. An attempt has been made to summarize the best treatment tested for each species (table 5).

Hardwoods Can Be Controlled by Aerial Spraying

In the Missouri Ozarks, low-quality hardwoods are seriously retarding the growth of a shortleaf pine understory. Recent studies have shown that one aerial application of 2 pounds of 2,4,5-T or 2,4,5-TP per acre can successfully reduce the hardwood competition. On such areas, the growth rate of the pine is comparable to that of pine released by hand.

SEEDING AND PLANTING

Direct Seeding Yellow-Poplar

A new study begun in southern Indiana is designed to find out if yellow-poplar can be artificially established in forest openings. Planting is being compared with direct seeding. Half of the

Table 5.--Best treatments tested by species

Species	Application: date	Treatment					
		2,4,5-T ^{1/}			Ammate ^{2/}		
		12 1/2 lb. AHG		50 lb. AHG			
		Percent	Relative	Percent	Relative	Percent	Relative
		kill	cost ^{3/}	kill	cost	kill	cost
Post oak	November	90	1.0			82	1.3
	February			96	1.3		
Blackjack oak	June			81	1.5	78	1.3
	February	78 ^{4/}	5.0 ^{4/}				
Black oak	June	73	1.0	84	1.5	76	1.3
White oak	June			91	1.5		
	November	79	1.0			79	1.3

^{1/} 2,4,5-T ester in fuel oil applied in low frill.

^{2/} Ammate in water, 4 pounds per gallon in low frill.

^{3/} Total cost for materials and labor for the least expensive treatment was about \$1.66 for 100 5-inch trees, or for 500 diameter-inches.

^{4/} Applied as basal spray.

planting and seeding was done on disked plots and half on undisked plots. Survival of planted seedlings is good and direct seeding shows enough promise to warrant further tests. The undisked plots were scarified during logging, and stocking of direct-seeded yellow-poplar was the same on disked and undisked plots.

Methods of Ground Preparation and Planting

Experienced tree planters know that the cost of planting varies a great deal with the methods of ground preparation and planting used, and that costs will differ from one site to another even when the same methods are employed. But what is less generally known is the relative success of these different methods in terms of survival and growth. Two experiments to compare success and costs were established in 1949 and 1950 on typical old-field sites in southeastern Ohio. All commonly used methods of ground preparation were tested, including planting trees on the "lay" of double furrows, in the bottom of single furrows, and in scalps, in "rips" created by single-tooth road scarifier, and no ground preparation. Trees were planted by the bar-slit, mattock, and machine methods. Yellow-poplar, eastern white pine, and red pine were used in the planting.

The results after 6 to 7 years show that, except for yellow-poplar, method of ground preparation and planting had little effect on survival and growth. Yellow-poplar growth was better on the "lay" of the double furrow.

Species Tests on Old Fields

In 1947 four conifer and three hardwood species were planted on two upland old fields in southern Illinois. Eleven growing seasons later the conifers had better than 84-percent survival and average heights ranged from nearly 10 to 24 feet (table 6). Survival of the hardwoods ranged from 35 to 66 percent and average heights ranged from about 4 to 8 feet.

Due to erosion the depth of the surface soil varied from place to place within the two old fields. The average heights and percent survival of conifers did not vary significantly with surface soil depth. However, the height and survival of the hardwoods varied with the depth of the soil (fig. 6).

Figure 6.--The effect of surface soil depth on the height of yellow-poplar. Trees planted on badly eroded areas averaged only 2.7 feet in 11 years. The pine in the background was unaffected.



Table 6.--Eleven-year survival and total height of seven
species planted on old fields

Species	Survival	Height
	Percent	Feet
Loblolly pine	84	23.9
Shortleaf pine	88	16.7
White pine	87	14.0
Eastern redcedar	87	9.5
Yellow-poplar	66	7.8
White ash	74	4.1
Black walnut	35	3.5

The results of this planting show that yellow-poplar, white ash, and black walnut should not be planted on badly eroded old fields. If considered for planting, these species should be located where the soil is several inches deep. The conifers, however, can be successfully planted on eroded old fields.

Growth of Planted Yellow-Poplar on an Old Field and a Forest Site

Yellow-poplar seedlings planted on a recently cleared forest area in southern Illinois grew much better than similar seedlings planted at the same time on an old field. This occurred even though the yellow-poplar on the forest site was competing with a dense growth of hardwood sprouts and seedlings. During the third growing season these seedlings averaged 6.3 feet in height compared with 1.5 feet on the old field. Survival was about the same on both areas.

Planting Studies in Iowa

Plots were established in northeast Iowa in 1949 to test the suitability of 30 conifers for planting old fields. The following species have shown the best growth and have a survival of at least 70 percent after 9 years:

Species	Height in feet
Jack pine	13.4
Pitch pine	10.4
Eastern white pine	9.3
Red pine	7.8
Austrian pine	6.7
Norway spruce	4.1
White spruce	4.1

In cooperation with Iowa State College, 26 different conifers were test planted in 1949 in the loessal-bluffs region in western Iowa. Survival and growth of most species have been adversely affected by prolonged droughts in early years, high soil alkalinity, heavy weed competition, and exposure. Much replanting and release have been required. The most promising species with a survival of about 50 percent or better for all trees planted since 1949 are listed below with average height at 8 years:

<u>Species</u>	<u>Height in feet</u>
Jack pine	10.1
Eastern redcedar	8.0
European larch	8.0
Rocky Mountain juniper	7.4
Ponderosa pine	6.2
Austrian pine	5.5
White spruce	4.0

Conversion Plantings

The poor showing of hardwoods on some ridges and upper slopes has created interest in converting stands on these sites to conifers. In general, conifers will grow better than hardwoods on poor, dry sites. Two studies in southern Illinois have produced some information on conversion planting this year.

In one test shortleaf pine and redcedar were planted under hardwoods and in different-sized openings created by cutting. Eight years after planting it is apparent that the height growth is directly related to the size of the openings. The poorest growth was made under the hardwood canopy. Thus, for best height growth, it is recommended that plantings of this type not be made in openings less than 100 feet in diameter.

In the other test shortleaf pine and redcedar were planted in a 16-acre, clear-cut area. All hardwood trees 5 inches d.b.h. or larger were either cut, killed, or destroyed by logging. Many of the smaller hardwoods were also destroyed by logging. Nine-hundred trees per acre were planted. Six years later 300 per acre were alive and thrifty. By that time, sprout growth was competing with the planted trees and a release was necessary. In 1957, two years later, 230 living trees per acre remained and a second release had to be made. The survival data make it clear that converting hardwood stands to pine can be costly in southern Illinois. This experience suggests that herbicides should be used to prevent hardwood sprouting.

In Iowa recent tests of converting low-grade stands by planting better species have produced good results and at the same time have introduced another problem. When the overstory is removed or killed, the weeds and shrubs usually grow extremely dense and only fast-growing planted species can survive.

A natural cross of bigtooth aspen and European white poplar found in southeastern Iowa has been outstandingly successful in the conversion tests. Rooted cuttings from two separate parent stands, designated the "Shimek" and the "Sherrill" strains, have grown 4 to 5 feet in height each year with a 75-percent survival. After 3 years, one Shimek hybrid is 21.5 feet tall.

Other species that have competed successfully with the weeds are cottonwood and yellow-poplar (which is not native to Iowa). Both species have grown more than 2 feet each year in spite of serious deer damage. Underplantings with conifers and such hardwoods as black cherry and basswood have not fared well. These species cannot be recommended for stand conversion until a practical method of reducing weed competition can be found.

In 1954 some studies to compare the yields of hardwoods and pine on some of the ridgetop sites on the Vinton Furnace Experimental Forest were begun. Six 1/2-acre plots were cleared of hardwoods and planted to a mixture of shortleaf, pitch, and white pine. On all of the planted plots sprouting of hardwoods occurred. To determine how this sprouting competition affected the growth of the pines, three of the planted plots were released by spraying the sprout growth with a herbicide. The first release was made in 1955 and a second was made in 1957. Results to date show that releasing definitely benefits the pine (table 7).

Table 7.--Survival and heights of the released
and non-released trees after 4 growing seasons

Species	Released		Not released	
	Survival	Height	Survival	Height
	Percent	Feet	Percent	Feet
White pine	92	2.4	81	2.1
Shortleaf and pitch pines	80	4.0	67	3.5

Strip-Mine Reclamation

Most of the year's work on strip-mine research was devoted to evaluating plantings in Ohio, Indiana, Kentucky, and Illinois begun more than 10 years ago (fig. 7). These results, soon to be published, show that as much care must be taken in choosing species for a site on strip-mined land as on old fields. The most important site factors to be considered when choosing species to plant are: (1) Acidity, (2) texture, (3) compactness, (4) topography, and (5) grading. Existing volunteer vegetation can also influence the choice of species.

In Ohio, for example, white pine grew three times faster on loose, shaly clays than on compact, calcareous clays. On the latter sites white ash grew as well on the upper slopes and ridgetops as on the lower slopes and bottoms. But on erosive, shaly clays, growth of ash in bottoms was three times greater than on slopes. Survival of silver maple in Illinois in five different localities ranged from 18 to 75 percent. The adverse effect of grading strip-mined land on the height growth is more apparent at 10 years than at 5 years.

Figure 7.--Plantings on strip-mined land in southern Illinois.



YIELD AND QUALITY

Managing Plantations

Pine plantations in the Central States are rapidly approaching an age when they must be thinned if good growth is to be maintained. Stands planted in the middle and late thirties are now old enough to produce posts, small poles, and pulpwood from thinnings. The Shawnee National Forest in Illinois recently sold 50,000 cords of pulpwood to be cut from pine plantations.

Seven years ago in southern Indiana a 14-year-old shortleaf pine plantation with 127 square feet basal area per acre was thinned to several densities of stocking. Remeasurement in 1957 showed little difference in basal-area growth between the thinned and unthinned plots. The unthinned plots now have 176 square feet of basal area per acre compared to 122 square feet for the plots thinned to 78 square feet. During the past 2 years growth on all plots has decreased slightly.

Another thinning study was begun this year in southern Indiana. A 17-year-old shortleaf pine plantation was selectively thinned to five levels of stocking. Before thinning there were 923 trees per acre which averaged 5.7 inches in diameter and 165 square feet of basal area. Mean annual growth has been more than 1 cord per acre per year. The heaviest thinning reduced the stand to 70 square feet of basal area on 365 trees per acre. The results of this initial phase of the study show that shortleaf pine plantations in southern Indiana can yield good returns from thinnings at an early age (fig. 8).

Optimum stocking studies were established in shortleaf plantations in southern Illinois. Stands on three different sites were thinned to 60, 80, and 100 square feet of basal area per acre. Four-year basal-area growth per acre per year is summarized below:

<u>Thinning level</u>	<u>Basal-area growth</u>
(Square feet)	per acre per year
	(Square feet)
60	8.0
80	7.7
100	7.6
Check (unthinned)	6.9

The degree of thinning had little effect on basal-area growth and only the check plots have made less growth than the average for the entire study. The growth is being concentrated on fewer and



Figure 8.--As many as 10 standard cords of excelsior wood and 360 fence posts per acre were cut in thinning a 17-year-old shortleaf pine plantation.

better trees in the thinned plots. Thus, if these early growth rates are maintained, increasingly larger trees can be expected in the more heavily thinned plots. During the first 4 years there was no difference in growth rates among sites. Eventually, this study should help to define the relationships between volume growth, stocking, and site quality.

Low-Grade Hardwood Stands Respond to Thinning

In the Missouri Ozarks, the basal-area-growth rate of low-grade hardwood stands increased after thinning. In stands cut to 27 and 53 square feet per acre, the average growth rate was fairly constant for the 17-year study period. Without thinning, the growth rate dropped when total stand basal area reached 90 square feet per acre.

Average annual growth percent was greatest for white and black oaks, and least for blackjack and post oaks. In unthinned stands, blackjack oak mortality exceeded growth. Mortality was greatest in the most dense stands, ranging from 11.8 square feet of basal area without thinning to 0.2 square feet where the stands were thinned to a basal area of 27 square feet per acre.

Growth of understory trees was closely related to degree of release. Basal-area growth per acre of these trees ranged from 77.8 square feet in plots with no residual overstory to 1.2 square feet in plots with 78 square feet of basal area in the overstory. In the understory the relative number of trees that grew from reproduction size to at least 1 inch in diameter during the 17 years was greatest for pine and black and white oak and least for undesirable species.

This study demonstrated that the net growth in the thinned stands was more than twice that without treatment. The increased growth on the better trees should make investment in stand improvement worthwhile.

Releasing Pole-Sized Trees

In Illinois the response to release of pole-sized white oaks is being studied on two sites: Good and poor. During March 1954, 140 trees were released from overhead shade and 56 trees were left unreleased. In most cases side shade on the boles of the released trees was maintained.

Two years after treatment all the released trees had responded to release with an increase in diameter growth rate. Trees on good sites grew slightly more than trees on poor sites; trees that were previously "fast" growers grew a little more than those that had been "slow" growers. These early results show that, despite previous suppression, pole-sized white oak trees will respond to release.

Stocking Structure in Upland Hardwoods

This year 20 half-acre plots were established in a comprehensive stocking-structure study in Illinois. Twenty plots were set up in 1955 and 20 additional ones will be located next year. The 60 plots on upland sites will be used to study the growth and quality of trees grown under 3 stocking densities and 3 stand-structure conditions.

The three stocking densities being tested are 40, 60, and 80 square feet of basal area. The three stand-structure classes are, small sawtimber in which most trees are 11 to 16 inches d.b.h., medium sawtimber with most trees 17 to 22 inches d.b.h., and large sawtimber with a high percentage of trees over 22 inches d.b.h. (fig. 9). The total of nine combinations of stocking and structure and a check plot will all be replicated three times on both good and poor sites.

More and more emphasis is being placed on high-quality wood production. The potential for increasing the quality of timber harvested is especially high in the Central Hardwood region. The problem of course is how to select and favor in the forest stand individual trees that will yield high-quality wood.

Hundreds of trees in the stocking-structure study are being carefully described. All faces of the bole of each study tree are diagrammed and defects shown to scale. In addition to this, tree characteristics including diameter, total height, merchantable height,



Figure 9.--This large sawtimber stand of upland hardwoods in southern Illinois is too dense for optimum growth.

crown length, crown width, and others are described. Future measurements of these and other trees will provide the basis for tree-quality classes. Further, the effects of stand structure and stocking on quality can be measured.

Growth of Reproduction Increased by Release

Many pine sites in the Ozarks are now occupied by low-quality hardwoods with an understory of shortleaf pine and hardwood sprouts. Studies conducted in southern Missouri show that complete or partial release of this reproduction results in better survival and growth for all species. During the first 11 years after treatment, completely released trees grew 4 to 5 times as much as those without release. Removing two-thirds of the overstory doubled the height growth during this period. When only one-third of the overstory was eliminated, height growth was about the same as that of unreleased trees.

The most important result of release was the great improvement in composition. Natural succession on pine sites in Ozark forests appears to be toward better quality stands of shortleaf pine and black and white oaks. Release accelerated this trend. Where at least two-thirds of the overstory was removed about 80 percent of the tallest 500 trees per acre were of these species. Light cuts removing only one-third of the overstory produced understory stands similar to those in untreated areas. The degree of improvement in composition was related directly to the degree of release.

Figure 10.--
Typical pin oak
stand found on
poorly drained
flatlands.



Pin Oak Silviculture

The pin oak type covers about 7 percent of all forest land in Illinois and about 7 percent of the bottomland forest in Missouri. These sites are usually poorly drained and their chief value is for forest production (fig. 10). Volumes found in unmanaged stands indicate that high yields are possible but little is known about pin oak management. The combination of frequent flooding and palatable acorns make pin oak stands an excellent habitat for migratory waterfowl. This has created much interest in the management of pin oak stands on the part of various conservation agencies.

The University of Missouri, the U. S. Fish and Wildlife Service, the Missouri Conservation Commission, and the Carbondale Forest Research Center are working cooperatively to find out how to manage pin oak for timber and mast production. Specifically these groups are seeking information on growth and yield of the species, tree quality characteristics, reproduction, and production of seed as affected by management and artificial flooding. Six different combinations of stocking structure are being tested.

The same cooperators have also completed the initial work in a pin oak pruning study. Pin oak is probably our poorest natural pruner. Lumber from this species is full of knots and the price for such material is very low. The objective of this study is to find out how to improve the quality of pin oak logs. Sprouting may cancel out the benefits of pruning, so trees have been pruned at three dif-

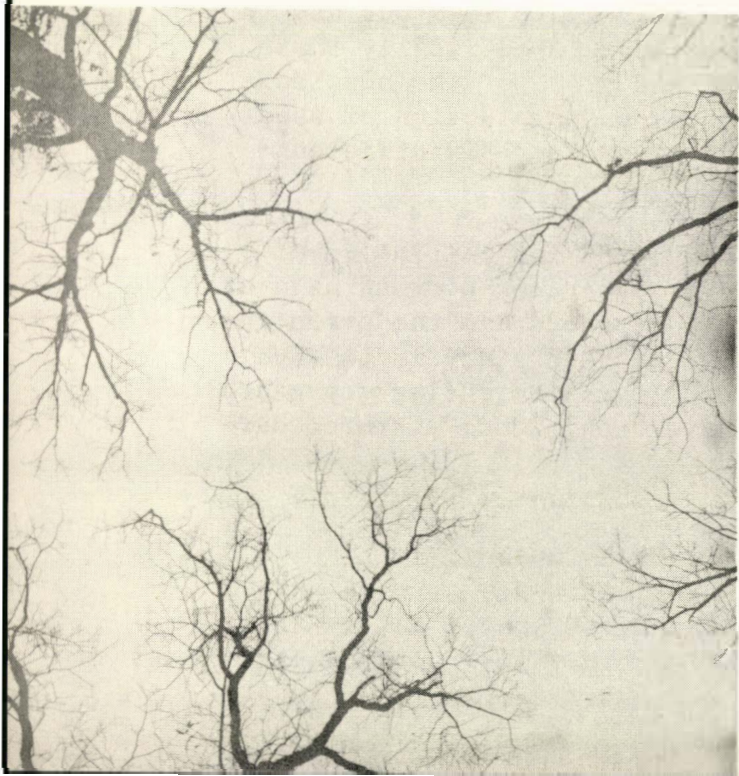
ferent times of the year to find out if season of pruning affects sprouting. A total of 150 pruned trees have been used in the study. Half of them have boles exposed to sunlight and half have shaded boles. The trees were pruned to 17 feet. Pruning time averaged 4 minutes per tree and an average of 35 branches were removed per tree. Eighty-five percent of the branches removed were dead.

Crown-Competition Factor - A Measure of Stand Density

Stocking studies in upland forests of eastern Iowa were begun in 1949 in oak-hickory stands 25 and 50 years old, and in 1953 in white oak stands 95 years old. The objective is to determine what stocking will yield optimum growth and greatest financial yield.

Although the stocking levels for the 25- and 50-year-old stands were determined on the basis of basal area, they can also be expressed in terms of "Crown Competition Factor"--a new measure of stand density developed at the Ames Research Center. The Crown Competition Factor is based upon average crown widths of open-grown trees of given species and d.b.h., and it is apparently independent of site quality and tree age (fig. 11). To date, maximum basal-area growth is occurring at a Crown Competition Factor of about 130 for 25- and 95-year-old stands. Corresponding basal areas per acre of this density of stocking for the 25-, 50-, and 95-year-old stands are 60, 78, and 93 square feet, respectively.

Figure 11.--Vertical photos showing white oak stand having Crown Competition Factor of 115 (left) and 160 (right).



CUTTING PRACTICES AND DEMONSTRATIONS

Managing Small Woodlands

Nearly 60 percent of the forest land in the Central States is in small farm ownership. Much of the remaining forest area is also in small private holdings. So it is plain to see that small ownerships must supply the bulk of future demands for timber. However, many small forests are low in productivity because of past burning, grazing, and high-grading.

Although most of our research is in some way related to the problem of increasing the amount, quality, and value of forest products from small ownerships, in several studies the small woodland itself is considered a unit of management in order to simulate the problems of the small owner.

Small woodland management studies in the mixed-hardwood and oak-hickory types in Kentucky have been established to find out how such stands can be rehabilitated and managed. In the first cut merchantable trees are being harvested and the culls are being killed. Indications are that this rehabilitation cut can be made at a small profit.

In 1948 a 23-acre tract of well-stocked upland hardwoods was set aside on the Kaskaskia Experimental Forest to demonstrate how such a tract might be managed. The tract was divided into three parts and one part has been cut each year. Each cut removed the lowest quality trees: Minimum cut was 600 board-feet per acre. After 9 years, the value of the products cut and delivered to the roadside was \$1,100, a gross return of about \$5.30 per acre per year for the entire tract. The original sawtimber volume was 96,000 board-feet. During the 9-year management period 40,000 board-feet were cut and the present volume is 89,000 board-feet. So the net growth has been 33,000 board-feet for 9 years or about 160 board-feet per acre per year.

In 1952 a 21-acre, poorly stocked stand was selected for a similar study. This tract had a volume of 65,000 board-feet and contained many poor-quality trees. A heavy improvement cut was made and 23,000 board-feet of logs valued at \$542 on the roadside were removed. Today the volume is 55,000 board-feet so growth has been about 124 board-feet per acre per year despite the original low stocking and the heavy cut that was made.

All the culls were killed in the well-stocked stand at a total cost of little more than \$2.00 per acre; the average tree

quality is better; and the growth rate has increased about 50 percent. In the poorly stocked stand a little more than \$3.00 per acre was invested to kill culls and the growth rate has also increased. In 4 years it appears that the tract will again have 65,000 board-feet but this volume will be on the best trees.

Upland Hardwoods in Illinois

In 1949, demonstrations of three cutting treatments were established in mixed-hardwood and oak-hickory stands on the Kaskaskia Experimental Forest. The treatments were:

(1) Intensive cutting--kill all culls and cut all merchantable trees except good growing stock.

(2) Extensive cutting--cut all merchantable sawtimber-sized trees except the best 15 per acre.

(3) Merchantability limit--cut all trees that were merchantable for sawlogs or mine props.

By 1957 board-foot volume in intensively cut stands had increased by more than 100 percent and growth was concentrated on the best trees (fig. 12). In extensive cuttings volume also increased more than 100 percent, but much of the growth was made in unmerchantable and low-quality trees. Where all the merchantable trees were cut, only a small percentage of the volume has grown back. Basal area has followed the same general pattern as volume growth except that the basal area was increased to a greater extent by added reproduction.

Pilot-Plant Management Area

In research it is not always enough to solve problems. Sometimes it is both necessary and desirable to demonstrate how to use the results in so-called "pilot plants." A 300-acre pilot-plant management unit on the Kaskaskia Experimental Forest has been set aside as a demonstration of practices found to be best for managing our hardwood forests. Here, the aim is to combine the best silvicultural practices known with simple and flexible methods of management that any forest owner could use.

By 1957 the rehabilitation phase in 8 of the 9 cutting units was completed. When the rehabilitation cut is completed, one or more compartments will be cut each year by the group-selection method on a 5-to-10-year cutting cycle. Costs of management and returns from products cut are recorded currently and will be an important factor in evaluating the success in managing this pilot-plant.

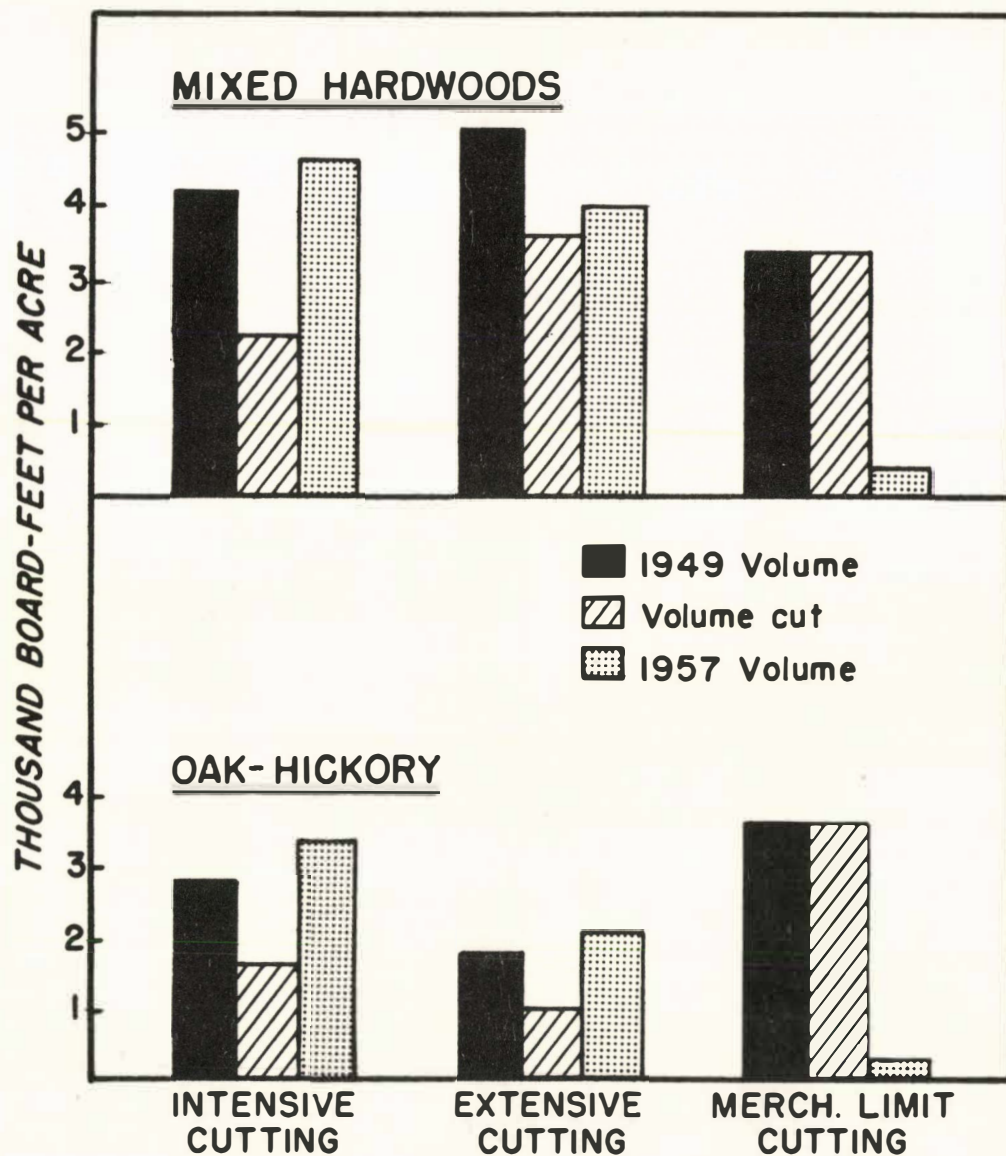


Figure 12.--Effect of cutting intensity on growth of residual stand.

Bottomland Hardwoods

Most bottomlands adjacent to major streams in the Central States are excellent for growing timber. Under intensive management the best of these sites will grow at least 1,000 board-feet of sawtimber per acre each year. Unmanaged bottomland forests contain large numbers of cull and low-quality trees so the first step in managing these stands is to eliminate these trees. But how does cutting in these stands affect growth and new reproduction?

To answer this question a series of replicated 2-acre plots was established in bottomland stands of southern Illinois. The stands consisted mainly of silver maple, cottonwood, elm, ash, and boxelder. In this test stands treated with three degrees of cutting and uncut check stands are being studied. The treatments range from clear cutting to light harvest cut. The 3-year growth is summarized below:

<u>Treatment</u>	<u>Residual stand</u> <u>per acre</u> <u>(Board-feet)</u>	<u>Net 3-year</u> <u>growth per acre</u> <u>(Board-feet)</u>
Clear cut	0	0
Heavy harvest and improvement	5,220	1,770
Light harvest and heavy improvement	7,070	1,690
No cutting	10,570	1,720

The actual net growth of all stands was nearly equal. The big difference among treatments is that the growth in the cut stands is concentrated on the best trees. Further, the growth percent, the return on the growing-stock capital, was more than twice as high in the heavily cut stands as in the uncut stands. Mortality ranged from 0.7 square feet of basal area per acre in the heavily cut stands to 8.1 square feet in the uncut stands.

It is too early to appraise the full effects of cutting on reproduction. But after 3 years, there has been a marked growth of seedlings to sapling size. By far the greatest change took place where cutting was heaviest. After 3 years the uncut plots have only one-third as many seedlings as the clear-cut or partially cut plots.

Economics

Forest economics research is aimed at providing timber owners, administrators, and the general public with information needed to profitably manage forest land and sell forest products. The work is divided into: (1) Collecting information on forest resources and forest industries to measure supply and demand trends, (2) marketing studies, and (3) other studies concerned with costs and returns, land ownership, taxation, and credit.

FOREST SURVEY

One job of the Forest Survey is to measure trends in demand and consumption of primary forest products so that future demands may be predicted. During 1957, 100 canvasses were made to determine the 1956 production of charcoal, veneer logs, and pulpwood in the Central States.

Charcoal Production Up

Interest in the charcoal industry in recent years stimulated a survey of all charcoal plants in the United States to determine production in 1955 and 1956. In the Central States charcoal production in 1956 was as follows:

<u>State</u>	<u>Number of Plants</u>	<u>Tons Produced</u>
Missouri	31	20,900
Ohio	4	5,500
Illinois and Kentucky	6	2,800
Iowa and Indiana	<u>0</u>	<u>0</u>
Total	41	29,200

This production was estimated to be 40 percent higher than in 1955. About 50 thousand cords of round wood and 19 thousand cords of mill residues were converted to charcoal in 1956. Oak and hickory made up more than 90 percent of the volume (fig. 13). Operators paid from \$6.00 to \$7.00 per cord for the wood burned and received from 20 to 4 cents per pound for the charcoal.

Veneer-Log Production and Consumption

About 55 million board-feet of veneer logs were harvested in the Central States in 1956; 10 percent of this volume was shipped outside the region to mills in nearby states. More than 60 percent was made up of walnut, cottonwood, and oak. About half the mills



Figure 13.--Typical charcoal kiln in Ohio. Kilns of this type are loaded with about 38 cords of slabwood and yield about 16 tons of charcoal.

using veneer logs produce container veneer but they used less than 40 percent of the total veneer-log receipts. Almost 90 percent of the veneer-log volume received at mills in Indiana, Kentucky, and Iowa went into face or commercial veneer; however, Ohio, Illinois, and Missouri mills put 90 percent of their log receipts into container veneer. About 16 percent of the 58 million board-feet of veneer logs received at mills in the Central States were imported from outside the region.

Similar canvasses are scheduled for alternate years to calculate and project trends in the production and consumption of veneer logs in the Central States.

Use of Hardwood Pulp Increases

Hardwood pulp is increasing in importance in the Central States according to a comparison of two recent canvasses of the pulpwood-using industries. Production in 1956 exceeded that of 1955 by 31 percent. Production varied by states as shown below:

<u>State</u>	<u>1956 Pulpwood Production</u> (Standard cords, unpeeled)	<u>Increase over</u> <u>1955</u> (Percent)
Ohio	95,300	17
Illinois	80,100	26
Kentucky	53,300	63
Indiana	22,000	- 1
Iowa	19,000	265
Missouri	2,400	100
Total	272,100	31

About half the volume came from "soft" hardwoods, 10 percent was pine, and the rest was "hard" hardwoods. Ten percent of the pulpwood produced in the Central States in 1956 was consumed at mills in Tennessee, Virginia, Pennsylvania, and Maryland. A similar canvass of the pulpwood-using industries will be made each year so that trends can be detected and measured.

Special Tabulations of Forest Survey Data

This year data from the initial Forest Survey in Ohio, Kentucky, Illinois, and Indiana were retabulated so that resource statistics may be easily compiled for small groups of counties. In the past few years such compilations were made for nine specific areas in the Central States in response to requests from interested groups. Most requests specify an area within a 50-mile radius of some strategically located city. By assembling the Forest Survey data taken in that area it is possible to give a fairly reliable estimate of volume by species and tree diameter.

MARKETING

Marketing Research Started in Kentucky

The northern Cumberland Plateau is an area of neglected forests, subsistence agriculture, little industry, and low income. As a result population in 35 counties declined 20 percent from 1940 to 1955. Standard of living and income are among the lowest in the country. More than three-fourths of this area is in timberland but the forests have been seriously depleted.

Forest economics research in eastern Kentucky is aimed at increasing the value of products being exported from the area, finding new markets for wood now unmerchantable, and determining financial yields of forests by sites and intensity of management.

Work has started by studying the forest-products market structure from the stump to the final manufacturer or user. This should reveal buying and selling methods, functions and procedures of buyers and sellers, and distribution of costs. This project forms the initial step in finding methods of increasing the product value exported from the producing area.

Another study in Kentucky is being made to find the relative value of trees when used for different forest products. Preliminary work has been on the financial returns from selling small-diameter trees for either cordwood or sawlogs. It was found that 6-inch trees must command a price per thousand board-feet Doyle

scale 16 times greater than the price per unpeeled cord before it pays to sell the tree for sawlogs, and for 12-inch trees it must be 4.4 greater to favor the sawlog sale over pulpwood sale.

Markets for Primary Products in Ohio

One of the big problems in timber marketing is the lack of market knowledge. Timber owners generally are unfamiliar with timber markets and marketing methods and with timber prices. Unless timber owners do have this kind of information interest in timber management will lag. Markets For Ohio Timber was published during the year as the Station's Miscellaneous Release 14. The release provides an up-to-date list of the 700 buyers actively in the market for rough timber products in Ohio. It also provides the usual specifications by which these products are purchased even though standard specifications for rough timber products are not yet recognized in Ohio. Prices buyers paid during 1956 were also obtained. This study was made in cooperation with the Ohio Division of Forestry. During the year, the market survey plan was revised and in December prices paid during 1957 were obtained.

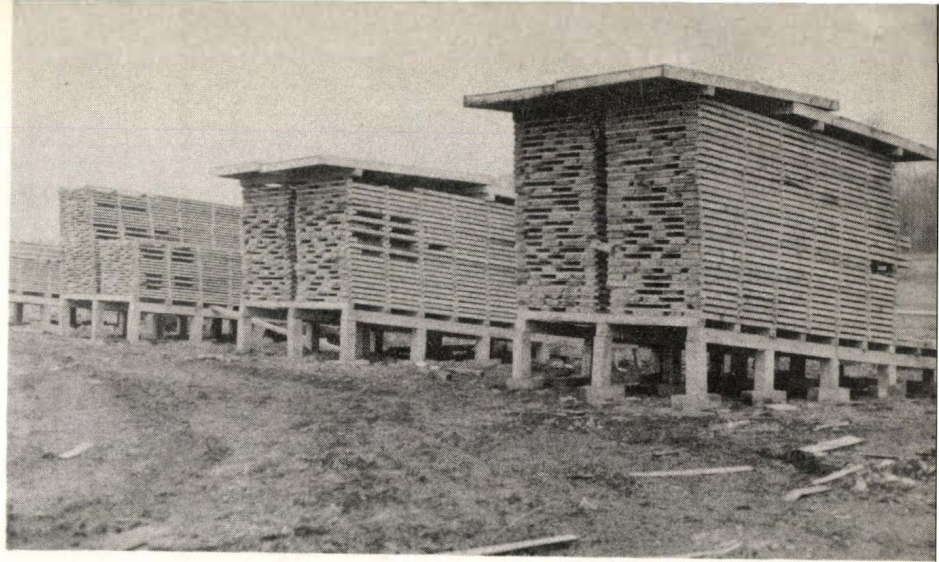
Marketing Air-Dried Factory Grade Lumber

Most hardwood lumber cut by small- and medium-sized mills in the Central States is sold rough green for local farm and industrial uses. Only a few mills grade and dry their lumber. Lumber that is air-dried and sold by grade brings a higher price. Many operators are aware of the price difference but are reluctant to undertake air-drying because they lack information on costs and methods and they may lack capital.

A case study of costs and returns of air-drying and selling lumber by grade was made at the Muskingum Watershed Conservancy District Sawmill. Methods and equipment considered applicable to the small mill operation were used. Red and white oak in Firsts and Seconds and No. 1 Common grades 4/4 and 8/4 thicknesses were used for the study.

Preliminary results show an increased gross return of about \$18.00 per thousand board-feet with allowances for shrinkage and degrade (fig. 14). Pile bottoms, covers, and handling cost a little over \$10.00. Shrinkage was 2.9 percent of total volume for all thicknesses, grades, and species. Principal sources of degrade were stain and end splits.

Figure 14.--Selling
air-dried lumber
can increase a
mill operator's
profit.

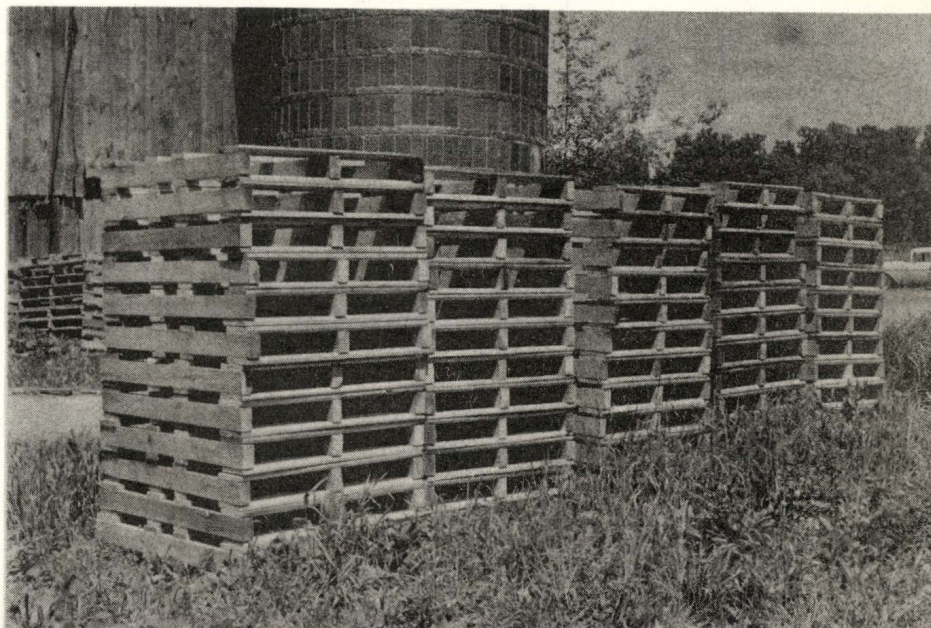


Outlook for Ohio's Forest Industry

Ohio is the second state in the nation in dollar value added through manufacture. Steel, metal products, and machinery are the most important products. But the manufacture of lumber, wooden articles, paper, and paper products is also important. In 1954, secondary wood-using industries accounted for more than 500 million dollars in value added by manufacture and employed 50,000 production workers. The primary wood-using industries are also increasing in importance. According to the last complete inventory of production from Ohio's forests, about 65 million cubic feet of timber are harvested annually.

In primary industries increased pulpwood production may be expected with the expanding use of oak and other hardwoods for pulp and paper manufacture. Industries that re-manufacture low-grade lumber are also likely to increase production of such items as pallets, crating, car blocking, farm building, and stock feeders (fig. 15). Timber market facilities are being improved.

Figure 15.--Low-
grade lumber is
being used in-
creasingly for
industrial pallets.



Christmas Tree Production

A cooperative study with the Ohio Agricultural Experiment Station's Department of Agricultural Economics has revealed that more than one and a half million Christmas trees are bought each year in Ohio; only 12 percent of these are homegrown. A few years ago none of them came from Ohio. In the future a larger percentage is likely to be Ohio-grown because twice as many Christmas trees were planted in 1956 as were planted in 1951. Right now growers are planting at the rate of more than 3 million trees annually. The average Ohioan who buys a tree usually gets it two weeks before Christmas at the first lot he visits at a cost of \$3.00 to \$8.00.

Other Marketing Studies

Timber suitable for lumber or ties can be marketed almost anywhere in Iowa. Good-quality walnut timber is in demand by veneer and specialty users. Buyers for pulpwood, basket timber, and stave timber also offer markets in some parts of the State. These facts were obtained by a survey of Iowa timber markets completed in cooperation with Iowa State College.

The use of hardwood slabs and edgings by the pulp and paper, charcoal, and metalurgical-chip industries of eastern Ohio has increased rapidly in the last few years. A number of companies are buying slabs by weight rather than volume. A study was undertaken to determine weight-volume relationships for bundled hardwood slabs. Results show that length of bundles is one of the greatest causes of variation in the volume-weight relationship. Bundles containing slabs cut to a maximum length of 8 feet weighed more per cord and had less variation than bundles cut to a maximum length of 10 feet. Species composition and moisture content were approximately the same for both bundle sizes.

A preliminary survey of the markets for rough lumber in Ohio was made in cooperation with the Ohio Division of Forestry. Firms of many types purchased rough lumber from Ohio sawmill operators. They included lumber concentrators and lumber brokers and firms that made and used crating, car blocking, boxes, and pallets. Manufacturers of truck and trailer bodies, furniture, flooring, brush handles, ladders, shoe heels, and livestock feeders and sheds also were important markets for native lumber.

TIMBER PRODUCTION ECONOMICS

Work in the field of production economics is relatively new at this Station and a brief description is in order. The objective of this research is to provide economic guides and procedures for forestry enterprises, and to appraise costs and benefits of public and private programs on forest land. Research in production economics can be listed under the following headings: (1) Forest production, (2) forest protection, (3) forest land use, (4) forest land ownership, and (5) forest finance.

Plantation Costs and Yields

Because of expected increased interest in tree planting due to the Conservation Reserve of the Soil Bank Program, some attention has been given plantation establishment costs and yields. Case studies were made but reliable results are not yet available.

Plantation establishment and yield studies are needed on an interregional basis. So this Station has joined with the Southern and Southeastern Stations to gather economic data for species common to the three territories. Within the framework of a general plan, each Station is establishing specific studies to obtain data concerning costs of site preparation, planting, thinning, pruning, and harvesting.

Forest Income in the Ozarks

Current interest being shown in low-income areas focuses attention on the Missouri Ozarks. The contribution that forestry can make to low-income farms should be significant in Missouri. One-third of the State is forested, and most of this resource is found in the low-income area. So the job ahead will be a big one for our new production economist in Missouri.

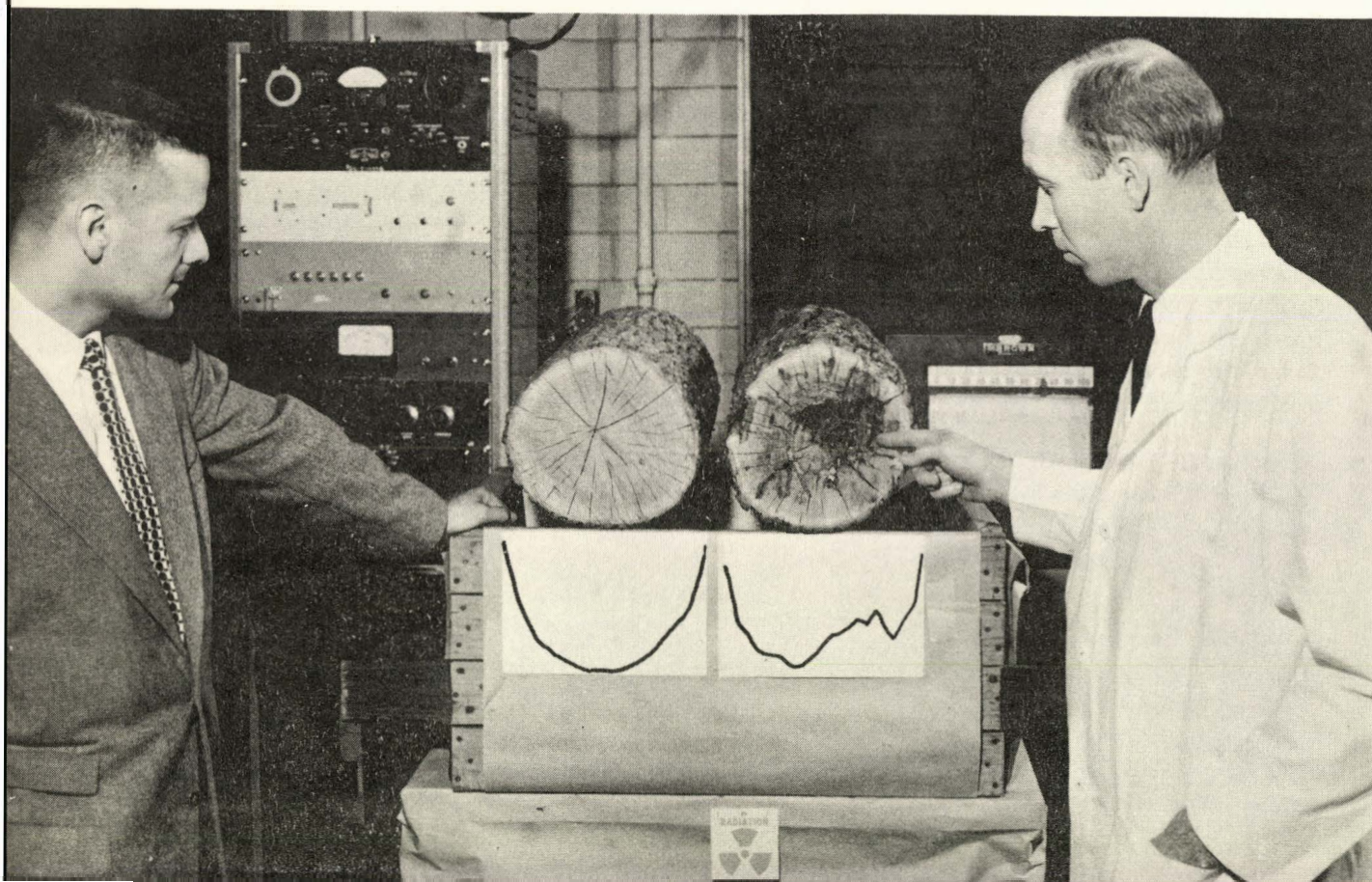
A study of the timber income potential on 153 sample farms in Dent County, Missouri is being made by a graduate student of the University of Missouri. Field work on sample farms is complete. Current market information remains to be gathered and applied. Past income will be compared with the present potential income from an assumed market utilizing the polewood timber stands now dominant in the area.

The study has been successful in the interview stages. Candid replies from persons interviewed check with observed ground conditions. The difficulty of obtaining exact values for wood volume removed and income received seems related more to lack of book-keeping than to any desire to withhold information. Income from the sale of forest products is not presently contributing much to individual farm income. And income that is received is low when compared with the volume of wood moving into the market. The study has emphasized the importance of markets and the needs for marketing research.

Gamma Rays for Measuring Cull

The Divisions of Forest Economics and Forest Diseases have a cooperative project with the Ohio State University to study the attenuation of gamma rays by wood (fig. 16). Recent studies show that fluctuations in moisture content have little influence on the penetration of gamma rays. Even in dense species, such as hickory, these fluctuations do not exceed 1 1/2 percent. So, variations in moisture content usually found in living trees will not greatly affect the accuracy of tests designed to measure decay. As a result, it is believed that standing timber can be successfully analyzed for cull by the gamma ray method.

Figure 16.--The uniform curve on the left shows the regular penetration of gamma rays through the sound log above it: The erratic curve on the right shows presence of decay in the defective log. (Ohio State Univ.)



Forest Products Utilization

This Division provides liaison service between forest products research and the wood-using industries and conducts the wood utilization research at the Station. Most of the research is done at the Wood-Products Pilot Plant and the Kaskaskia Experimental Forest of the Carbondale Center. Also, a few studies are carried on cooperatively with forestry schools and forest industries within the Station's territory.

Emphasis at the Wood-Products Pilot Plant has been on finding new uses and better processing methods for hardwood lumber. At the Kaskaskia Experimental Forest, work is concentrated on harvesting and sawing problems. Methods for getting more high-quality lumber from hardwood logs are being developed at the sawmill in cooperation with the Forest Products Laboratory. In the woods, attempts are being made to lower production costs in felling and bucking, to improve the grade of logs by better bucking practices, and to simplify methods of estimating quality in standing trees. All these studies should help solve one of the most important problems in the Central Hardwood Region--providing outlets for the large volumes of little-used species and low-quality timber in the Region.

PRIMARY CONVERSION

Estimating Quality in Standing Trees

Most woodland managers and loggers in the Central Hardwood Region realize that in appraising timber stands quality as well as quantity must be considered. At the Carbondale Center several methods of predicting tree quality by grading an "indicator section" of the stem are being explored.

Tree-quality data are being collected for 15 hardwood species or species groups. So far data from approximately 400 black oak and upland red oak trees show that the best 10-foot section of the 16-foot butt log is a good indicator of the quality of factory-grade lumber contained in trees of these species. Tentative tree grades based on this method were developed for black oak and the grades were field checked on 76 trees in the Kaskaskia Experimental Forest. The graded trees were then felled and bucked by a crew working independently of the grader. In bucking, the crew tried to cut as much volume as possible in grade 1 and 2 logs without seriously reducing production. Then all logs were scaled and graded and Forest Products Laboratory lumber-grade-recovery data were used to compute

the "actual" value of the lumber in the logs. These "actual" values were then compared to the values predicted by the use of the tree grades.

Discounting errors in estimating net board-foot volumes of standing trees, the predicted value of the 76 oaks (16,060 board-feet, International 1/4" Rule) was \$1,143.83. The "actual" value was found to be \$1,103.83--a difference of less than 4 percent.

Thus, it appears that an accurate easy-to-use method for estimating quality in standing sawtimber may soon be available.

Felling and Bucking

At the present time, at least 95 percent of the felling and bucking by logging crews in the Central States area is done with gasoline-powered chain saws. Most felling and bucking crews range in size from 1 to 4 men. Nearly all of the chain saws are either direct drive or reduction drive. The direct-drive saw is lighter, has a faster chain speed, but less lugging power.

One of the most promising means of reducing logging costs is to use proper, modern equipment. A study is now in progress at the Kaskaskia Experimental Forest to learn more about the effect of saw type and crew size on felling and bucking costs for different logging conditions. Since the study began, 12,500 board-feet of mixed hardwoods have been cut by a 2-man crew using a 6-horse-power, direct-drive saw. Preliminary results show that 52 percent of total crew and equipment time was used for "productive" felling and bucking when the saw was actually cutting wood. Six percent was spent moving between trees and 42 percent of the time was consumed by "non-productive" operations such as chain sharpening, chain adjustment, and crew rest periods. With the 2-man crew and direct-drive saw, total productive and non-productive time has averaged 46 minutes per crew or 1.5 man-hours of labor per thousand board-feet of timber felled and bucked.

Roofs on Lumber Piles During Air-Drying Pay Off

It is generally known that lumber air-dried in roofed piles usually develops less drying degrade than lumber dried in unroofed piles. But due to the cost of building, maintaining, and handling roofs, much lumber is air-dried without covers.

A study at the Kaskaskia Experimental Forest shows that it pays to use roofs on 4/4-inch commercial red oak lumber during air-drying. Results for two different seasons show that little degrade developed in properly stacked and roofed piles of No. 1 Common and Better lumber. However, in unroofed piles most boards in the top

4 courses dropped at least one grade during air-drying. In 6-foot wide piles the degrade resulted in a difference in air-dry lumber value of more than \$6 per thousand board-feet between roofed and unroofed piles. Thus, for No. 1 Common and Better red oak lumber, a roof costing \$25 to build and \$1 to set and remove would more than pay for itself in 6 uses when only savings in lumber degrade are considered.

So far, differences in degrade between roofed and unroofed piles of No. 2 Common and No. 3 Common red oak lumber have resulted in value differences of less than \$2 per pile. It appears that the use of a conventional roof for these grades cannot be justified on the basis of savings in degrade alone.

In some instances, the use of roofs may be justified for any grade of lumber because of more rapid and uniform drying. After a 90-day period during a wet spring season, boards in three unroofed piles ranged from 15- to 48-percent moisture content and averaged 26 percent. During the same period, boards in three roofed piles dried to an average moisture content of 18 percent, with individual boards ranging from 15 to 20 percent. However, during a dry summer season, roofs did not significantly affect the rate or uniformity of drying.

SECONDARY UTILIZATION

Wood-Products Pilot Plant

The over-all purpose of our secondary wood utilization research is to promote more complete and efficient use of the Central States timber resource. Most of this work is conducted at the Wood-Products Pilot Plant in southern Illinois. The plant is operated as a cooperative project between the Carbondale Center and Southern Illinois University. The equipment is used about half the time by the University for training vocational students.

The Pilot Plant covers several acres and includes an air-drying yard, facilities for dip and soak preservative treatments, a 6,000 board-foot capacity dry kiln (fig. 17), and a shop with 10,000 square-feet of floor space. The shop is equipped with modern heavy-duty, woodworking equipment. During the past year, several new pieces of equipment were acquired and now many types of commercial woodworking operations can be done.

Research in the Pilot Plant is designed to find new and improved uses for hardwoods. Efficient and economical methods will be developed for manufacturing products from different grades of native hardwood lumber. Most studies will be designed to secure marketing information on the type of product developed.

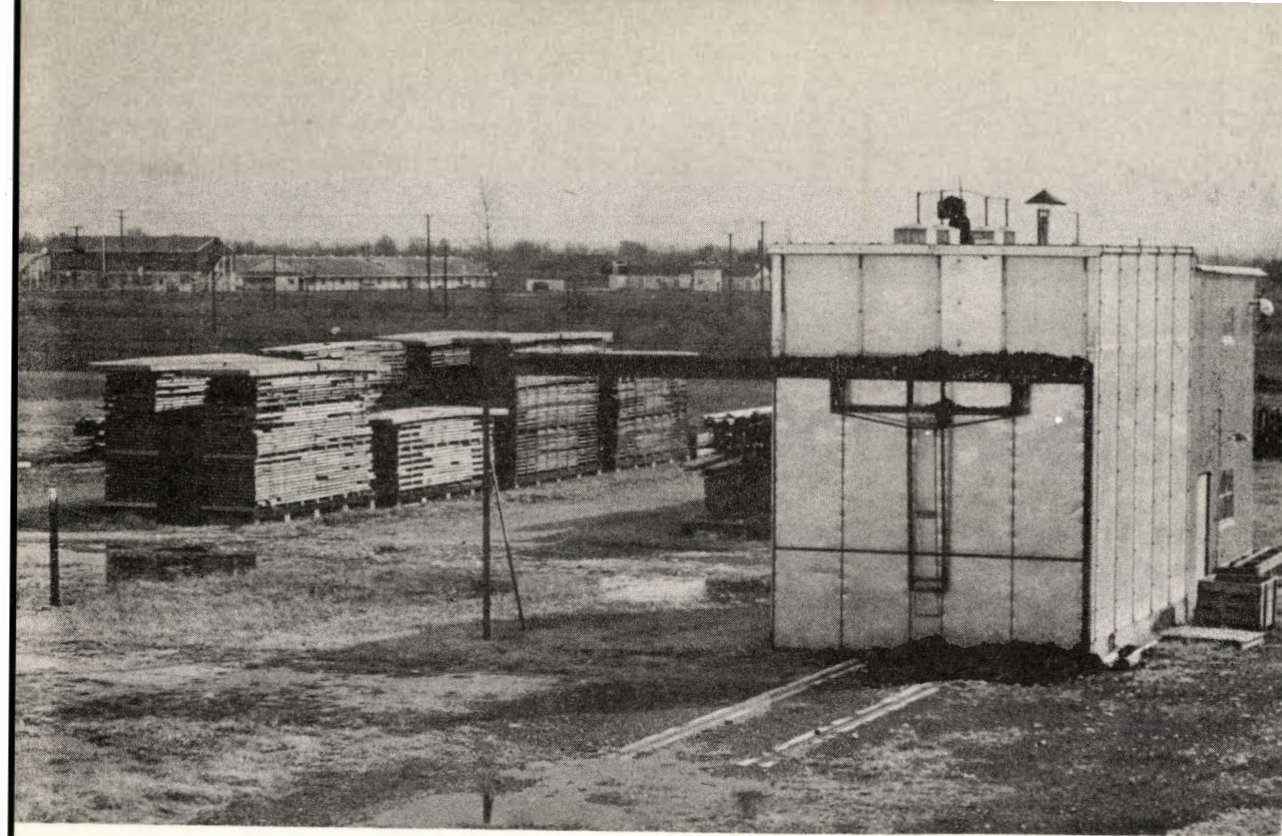


Figure 17.--Wood-Products Pilot Plant experimental dry kiln and air-drying yard.

Hardwoods for Farm Structures

Much lumber imported from other regions is used every year in the Central States to produce feeders, shelters, and other small, portable farm structures. Animal husbandrymen, agricultural engineers, representatives of farm management groups, and several manufacturers of farm structures have been consulted about using hardwoods for farm structures. It is believed that many hardwoods can be used to produce satisfactory structures that can compete with those on the market. If this can be done, a much-needed outlet for homegrown timber would develop.

With some assistance from interested groups, a hog-feeder, a farrowing crate, and a portable hog shade and shelter have been designed and built from red oak. All three units are being tested on the Southern Illinois University Experimental Swine Farm. A study dealing with hog-feeder production and design is now underway.

The production phase of the hog-feeder study is being conducted at the Wood-Products Pilot Plant. Objectives are to determine (1) if a salable feeder can be produced from red oak lumber, (2) how to produce it, and (3) what effect feeder size has on

recovery from various grades of material. Results to date indicate that a 12-door feeder can be made from about 270 board-feet of 2 and 3 Common oak for several dollars less than most wooden feeders of the same capacity now on the market (fig. 18).

A farm supply company is cooperating in the study by marketing the oak feeders manufactured in the study. Feeder buyers will be interviewed to gather information on user-acceptance and to determine the size and kind of hog-feeding operation that constitutes the best market for this type feeder.

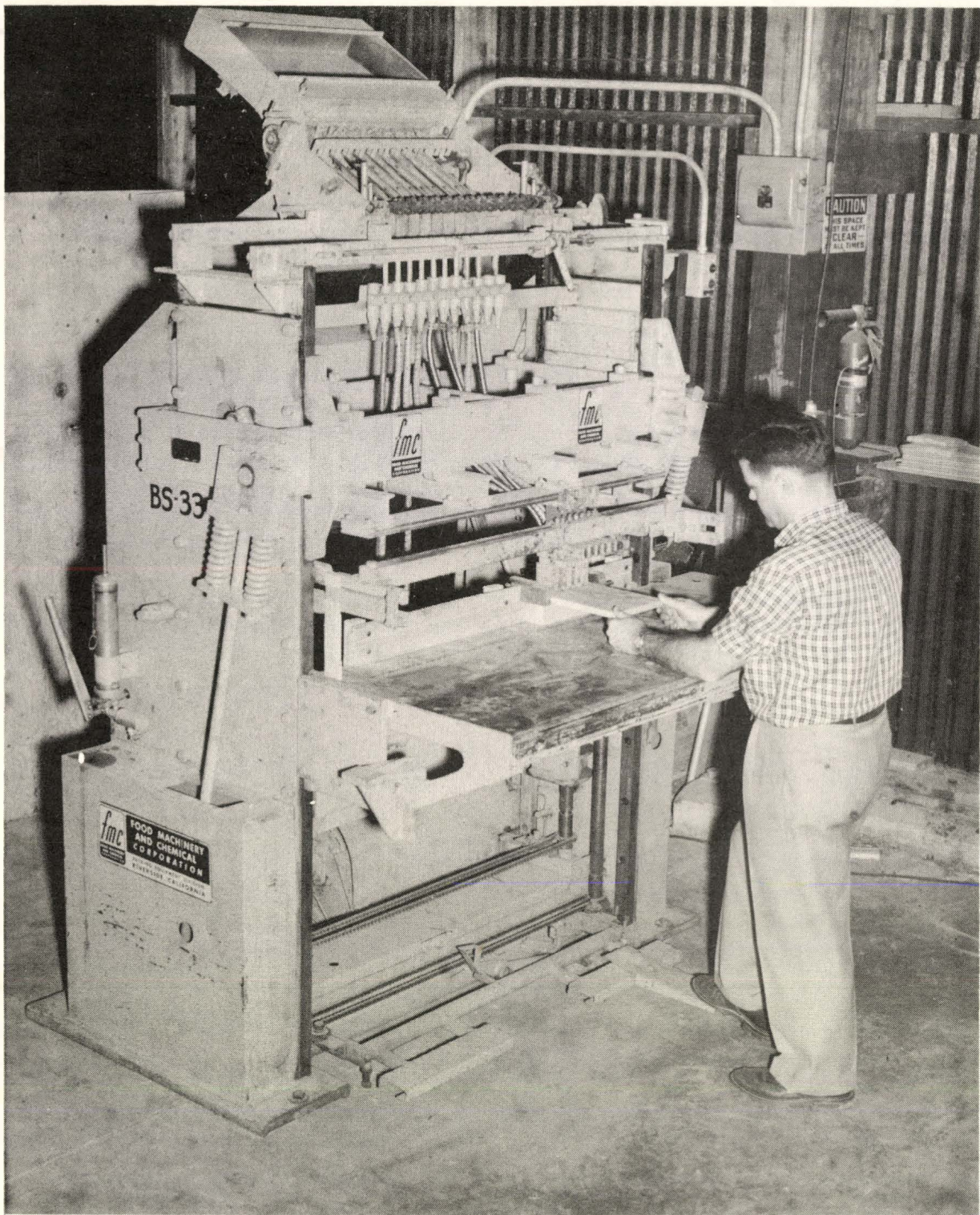
Nailing Hardwoods

Many dense hardwoods are not used for construction because they are hard to nail and split more readily than softer woods. Moreover, nail bending is often a problem in fastening hardwoods. The development of better nailing techniques for dense hardwoods should greatly increase their utility as construction material.

During 1957 a study was begun in cooperation with the Forestry Department of Iowa State College to find out how shank diameter, type of point, spacing, and position of smooth-shanked nails affect splitting and resistance to direct withdrawal in air-dry red oak (fig. 19).

Figure 18.--
Experimental
oak feeder.





Other Studies Are in Progress

Some other studies active in 1957 were (1) sawing techniques for improving the lumber-grade recovery from hardwood logs, (2) exploratory tests of predrying lumber in a kiln using forced, unheated air to speed up drying, (3) data analysis of the tractor skidding study, and (4) a survey of wood-chip-using industries in Illinois and Iowa to secure opinions on the use of portable chippers.

UTILIZATION SERVICES

Assistance to the wood-using industries in their utilization and production problems continues to be an important job of the Columbus staff. Requests range from equipment and processing problems to inquiries on wood-industry prospects in the Central States. A number of these requests have been handled jointly with the Station's Division of Forest Economics, particularly those involving resource evaluation.

Our Carbondale Center also devotes time to problems of wood-using industries in southern Illinois and adjacent states. During 1957 part of the utilization staff at Carbondale participated in a lumber-grading clinic in southern Illinois. In May, a sawmill clinic was held at the Kaskaskia Experimental Forest for foresters of the Illinois Division of Forestry. This fall, two of the staff members conducted a series of sawmill clinics in Iowa in cooperation with the Extension Forester. Throughout the year many visitors, including groups from forestry schools, industry, high schools, conservation organizations, and the general public, were conducted through the Pilot Plant.

(Left) Figure 19.--A 12-head, open-back nailing machine being used in a red oak nailing study.

Forest Fire

Better Land-Use Good Fire Prevention Tool

There are many ways to approach the problem of fire prevention. One way to change the attitude of some farmers towards woods burning is to demonstrate better methods to improve their range and pasture land. A study of converting unwanted woodland to range shows that a typical range fire in poor hardwood stands does not kill the trees so it is not worth the effort in terms of forage (fig. 20). If the trees are killed with herbicides the response of forage is good (fig. 21).



Figure 20.--Two years after spring burn. Native and planted grasses under a hardwood overstory responded very little.



Figure 21.--Two years after the understory and overstory were killed with herbicides. Planted little bluestem is making good growth and many other grasses and forbes are present.

Overgrazing, particularly on burned range, will cause native perennial grasses to decrease and weeds to increase. This was demonstrated by clipping all new growth weekly on unburned and burned land supporting vigorous native little bluestem for one season. More than 95 percent of the plants died but mortality began sooner on the burned plots. Overgrazing may have been more important than burning in deteriorating the native range, but burning in combination with overgrazing hastens deterioration. And burning may even increase the woody plants on some land.

Because as much as two-thirds of the pasture and range in Missouri is wooded, well-planned shifts of livestock to cleared and managed ranges should result in less burned forest land. This could be especially true of forest now in small private ownerships.

Progress in Fire Reduction is Encouraging

The effect of fire prevention can be measured by comparing the actual number of fires with the number of fires that could be expected under the conditions that existed. The Salem Ranger District, Missouri National Forests, was sampled in 1957 and only 30 percent of the expected number of fires occurred during the months of February, March, April, and October. The District showed a downward trend in the ratio of actual to expected fires over a 12-year period. This shows progress in fire prevention. Education, stepped-up law enforcement and investigation, and a decreasing rural population probably contributed to this progress. The real test will be to hold the number of fires consistently below the expected number in years of high fire danger.

Fewer forest fires occurred in Missouri during the first 10 months of 1957 than in any year since protection began in 1933. There are several reasons why this record was possible. The amount and distribution of rainfall was good. There were fewer days when relative humidity was less than 60 percent, which is an approximate measure of the opportunity for fires to occur. And at no time during the spring season of 1957 did the duff layers of the forest floor become fully dry.

Wind Forecasts and Fire-Danger Estimates

Weather forecasts are important for estimating fire danger and for planning presuppression. Wind direction and velocity are often the most important forecast elements, but in Missouri it is necessary to adapt the wind forecast made for airports. A study is being made to find out how forecast-wind velocity compares with observed-wind velocity at fire-danger stations. Winds at two fire weather stations were compared with forecast winds and the results

show that tomorrow's estimated fire danger can be improved by simply reducing forecast winds by half. Weather Bureau personnel felt that the forecast accuracy could be improved and they worked out a technique to forecast winds that gives good results for the airports at Vichy and Springfield. These locations are key stations in making the fire weather forecasts for southern Missouri. A comparison of observed winds at the airport station and observed winds at fire-danger stations agrees closely with the 50-percent reduction found when forecast winds were compared with danger-station observations. Some directional correction may be required but it is expected that improvement in the use of wind forecasts will be forthcoming.

In some regions there is a strong correlation between wind direction and relative humidity. But a study in southeast Missouri showed very little correlation in either the spring fire season or the fall fire season. The prevailing weather situation evidently has more bearing on relative humidity than does wind direction in this area, so forecast relative humidities must be used for planning purposes.

Hardwood Surface Fuels Measured

Fuel is an important variable that can be used to predict fire behavior. Leaf and twig litter are the most prevalent fuels in the forests of the Missouri Ozarks. Studies are being carried out to learn how fuel volume varies with tree species, past treatment, density of cover, soil, and aspect.

Measurements this year were confined to hardwood stands. On six plots the depth of forest floor and the total dry weight of litter and duff were sampled. A typical ridgetop hardwood stand, protected from fire for 20 years, has 86 square feet of basal area, 2,000 trees per acre, and a total of 8.7 tons of litter and duff per acre averaging 2 inches deep (fig. 22). Nearly 4 tons of this was loose litter--the part that burns most readily.



Figure 22.--This 2-inch deep hardwood litter and underlying duff weighs nearly 9 tons per acre oven dry.

Forest Insects

Preventing or reducing losses to forest trees caused directly or indirectly by insects is the chief aim of the work in this Division. Ways must be found to prevent and control insect damage to forests and forest products.

Before research in control methods can be started it is often necessary to study the life history of a particular insect so that treatments can be applied at the "right" time. Such is the case in the Central States because many insects have not been studied in detail. Much of the current work is in this direction. Another important job assigned to this Division is that of detecting and appraising insect outbreaks. Here the staff relies heavily on cooperation from foresters and others throughout the Central States region.

Small Oak Barkbeetles Can Transmit Oak Wilt

Studies conducted in Missouri have shown for the first time that the small oak barkbeetle (Pseudopityophthorus minutissimus (Zimm)) can spread the oak wilt disease. The disease developed in 3 of 241 seedlings exposed to the beetles. The tests began in 1952 and three sources of inoculum, 2 methods of insect release, and 150,000 beetles were used on caged seedlings.

Oak wilt disease developed in 1 of 117 seedlings fed upon by about 900 beetles that emerged from naturally infected bolts placed in cages that enclosed the entire tree (fig. 23). The disease was also found in 1 of 87 trees that were fed upon by 200 beetles reared in the laboratory from naturally infected bolts and caged on the upper part of the stem. Typical symptoms developed in 1 of 13 trees that were fed upon by 55 beetles that were reared from bolts artificially impregnated with the fungus and placed in a cage that enclosed the seedling. However, the fungus could not be recovered from the seedlings. None of the other test trees developed oak wilt symptoms.

The successful transmission of the oak wilt disease in these studies is evidence that the small oak bark beetle may help spread the disease. However, the percent of beetles that transmit the disease must be extremely small, otherwise, the incidence of oak wilt would be much greater.



Figure 23.--"Sleeve cages" were used on test seedlings. Insect-infested bolts as well as living insects were placed in such cages.

Other Oak Wilt Vector Studies

An exploratory study was made to find out what insects might spread oak wilt through tree wounds. An auger hole $1 \frac{3}{4}$ inches in diameter and 2 to 3 inches deep was bored into the stem of each of 200 black and scarlet oaks during the period April 9 to May 7. A metal screen cone was placed in each hole so that the insects would be trapped inside. The common woods roach was more abundant than all other insects trapped.

Oak wilt developed in 1 of the 200 wounded trees. Roaches were the only insect trapped in this tree during the first week after wounding. Since none of the other trees in the study area developed oak wilt symptoms, it is possible that the inoculum was carried to the tree by the roaches.

In 1956 a test was started to find out if the small oak bark beetle will transmit oak wilt in the field. Beetle infested portions of trees that had been inoculated in August 1956 with the albino strain of the oak wilt fungus were piled in the center of a $\frac{1}{10}$ -acre circular plot in March 1957.

The albino strain of the fungus was used because it has not been found naturally in Missouri. About 30,000 beetles emerged from the brood material between early April and late May 1957. These insects fed heavily in twig crotches at bases of leaf petioles, and on

small branches at rough spots in the bark of trees near the pile. Feeding was especially severe in trees nearest the brood material. To date there is no evidence that the trees in the study area have become infected with the albino strain of the oak wilt fungus.

In oak wilt vector tests in Ohio beetles of the genus Pseudopityophthorus and another beetle, Graphisurus fasciatus, were studied. The beetles were contaminated with the albino strain of the fungus. The insects were caged on parts of oaks. None of the trees used in the Pseudopityophthorus tests have exhibited foliar symptoms of oak wilt to date although every tree tested was fed upon to some degree. In tests using G. fasciatus the albino strain of oak wilt has been recovered from 3 trees. None of these tests are conclusive and all studies will be continued.

A 5-replicate cage plot was established at the Columbus laboratory for future use (fig. 24). Each of these cages is 6 feet high, 12 feet wide, and 24 feet long and will provide an insect-free environment for testing future insect populations. In each of these cages red and black oaks were planted at random with each tree site being banded to a depth of 3.5 feet to prevent root grafting. Thus, 4 replications of potential vector studies and one check plot are possible.

Hardwood Borers

Much degrade and cull found in hardwood sawlogs results directly from boring insects that attach standing trees. One mill study in Kentucky showed that 38 percent of the volume of oak logs was damaged by borers. A cooperative study was conducted with the Kentucky Agricultural Experiment Station to relate past borer attacks with site and environment. As expected, the upland oak type was the most severely damaged and fire played an important part in increasing the borer population. More important, it was found that heavy logging increased borer population.

Figure 24.--New cage plot at Columbus insect laboratory.



Much of the desirable merchantable timber was cut on the study area in the early 1920's. In the years immediately following logging the borer population increased sharply in the residual oak timber. The borer population was fairly high for the next 25 years. There has been a slight drop in number of attacks in the past 10 years.

The study also showed that in eastern Kentucky the most damaging borers are the carpenter worm, beetles of the genus Goes and the red oak borer. Trees most severely attacked are black oak, scarlet oak, and red oak. These species are about equally susceptible to borer attacks.

This year a study was begun on the Baldrock Experimental Forest to find out if there is a relationship between borer populations and the amount of basal area after logging. If a relationship does exist, hardwood borer damage might be reduced by modifying cutting practices.

Borers Controlled in Yellow-Poplar

A borer, Euzophera ostricolorella, was found killing mature yellow-poplar trees in western Kentucky in 1954. The larva of this moth feeds only in the phloem tissue of the root collar on yellow-poplar. Infested trees were salvaged but this did little to reduce the borer population because broods in the stumps were able to complete development. However, stumps evidently were undesirable for egg deposition because population of the next generation was low.

Two spray treatments were tried: A water emulsion and the other was an oil solution of 1/2 percent gamma isomer of benzene hexachloride plus 2 percent DDT. The oil solution was better than the emulsion and control was good. Since the tests were completed the borer population has decreased.

Biology of Boring Insects

Observations continue on the life cycle of the pinworm. This insect attacked several living black and scarlet oaks that were blazed in 1955. In 1957 the larvae continued to push out quantities of frass through pin-sized holes in the exposed xylem, but no adults emerged. Two adults emerged from trees that were blazed in 1954. This indicates that this insect needs at least 3 years to complete a life cycle.

Observations were continued on trees that were infested with carpenter worm larvae through blazes made in 1956. So far, five adults have emerged. Since both pinworms and carpenter worms are

responsible for much degrade in oak timber, additional research is needed on the biology, actual extent of damage, and possible control of these insects.

Virus Control of the European Pin Sawfly

European pine sawfly (fig. 25) population in the Ohio virus treated plots was lower in 1957 than any time since the tests were established 5 years ago. Plots treated in 1953 by airplane were generally free of sawfly. Plantations treated by airplane or hydraulic sprayers in 1954 and 1955 had 1 to 5 sawfly colonies per tree at the time of hatch in 1957. Later observations showed that the size and number of these colonies was reduced by the virus disease.

An 8-acre plantation was treated in 1955 but complete sawfly defoliation continued through 1956. In 1957 approximately one-fifth of the red and white pines in the plantation were from 50 to 100 percent defoliated, and the remaining trees were in poor condition. The polyhedra virus count of the spray used on this plantation was not known, so the poor results are probably due to a low concentration of virus. The virus disease that now exists should be sufficient to reduce defoliation to minor importance in 1958.

Figure 25.--The larvae of the European pine sawfly feeding on a pine needle.



A light infestation of sawfly is necessary to maintain the virus disease in a plantation. Should the sawfly become exterminated in a plantation, reinfestation of disease-free sawfly can be expected, followed by a heavy defoliation.

A limited supply of sawfly virus suspension is maintained at the Columbus Forest Insect Laboratory for distribution to Federal, State, and private agencies. Small supplies have been shipped to Indiana, Illinois, and Iowa.

Genetics and Systemics - Two Approaches to Insect Problems

Unfortunately, methods for controlling insects in homes, gardens, and farms are not practical for use in the forest. So, new methods must be developed. Two principles of control are being studied in Ohio. One method is through genetics--selection of resistant trees. The other is through systemics--application of toxic chemicals to the stem or soil which are absorbed and translocated throughout the tree.

The present work in genetics is limited to selections of trees with apparent resistance. Because black locust is common and locust borer infestation is usual, locust was selected for study. Ten strains of black locust have been multiplied by clonal propagation for planting in 1958. The interaction of site with genetic characters will be tested by planting trees of each strain on four different sites.

Systemic chemicals are being tested for controlling the locust borer on black locust and the elm bark beetle on American elm (fig. 26). Although treatments have made foliage toxic to sucking insects, toxicity in trunk tissues has not been great enough to exclude black locust borers. Dissected trunks of treated locust trees were examined and borer larvae were present. Elm bark beetles fed on branches collected from treated trees without reaction.

Control of Pine Shoot Moth by Spraying

In 1957 on an area where spraying was planned, about 16,000 European pine shoot moths were collected in all stages of development to find out the natural mortality pattern. Examination of these insects showed that none had died because of extreme cold. Mortality due to parasites was 20 percent.

Experience reveals that spraying in July is better than spraying in April because April spraying nearly eliminates the parasites and predators. And unless there are some natural enemies of

the shoot moth to control those that survive spraying and overwintering, there is likely to be another outbreak the following year.

A test of insecticide sprays for control of the European pine shoot moth showed that 6 percent DDT is better than 3 percent DDT. The wetting agents TX-100, TX-155, and aqua-gro add to the effectiveness of the mist. TX-100 was superior to the others.

Control of European Pine Shoot Moth by Systemics

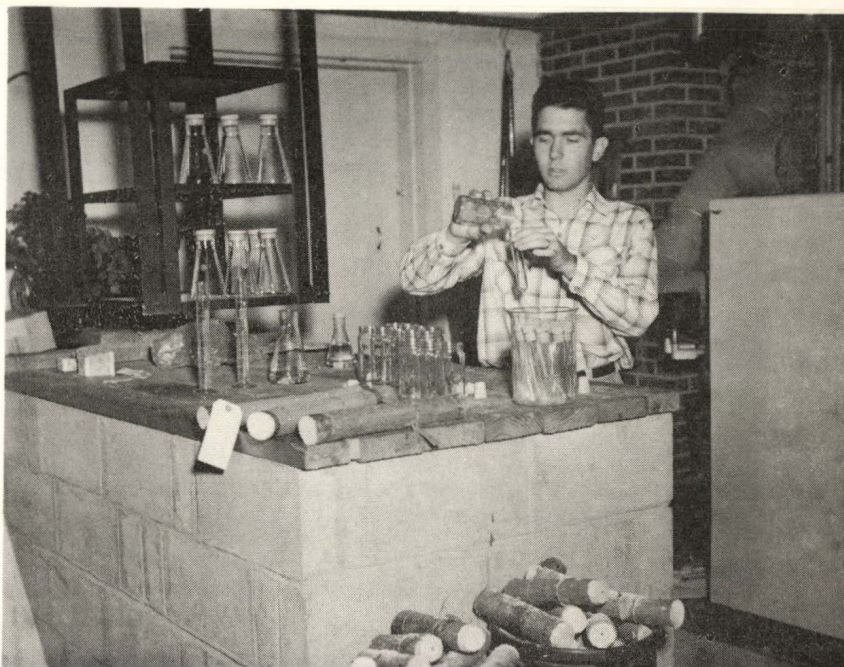
A greenhouse experiment with 3-year-old red pine heavily infested with European pine shoot moth showed complete systemic control with Phosdrin. Dosages were 0.5, 1, and 2 mls. of Phosdrin applied to the trunk. No injury to the plants due to the treatment were noted at any dosage. Bio-assays of residual effects in buds and needles were made using daphnids. After 5 days all of the treatments had lost their effect.

This information was used to design a field study. Ten 6-year-old red pines were treated at weekly intervals with 10 mls. of Phosdrin on trunks. Work began before the shoot moth larvae resumed activity and terminated with pupation. In 1957 this period was about 9 weeks, from April 1 to June 30. All of the treatments were aimed at controlling the pre-pupal instar.

Sixteen percent of the shoots on each check tree had at least one living larva. The average reduction in shoot moth population for all the 10 treatments was 98 percent. The first and last treatment gave a little less control than the others. Plant injury was heavy in applications made on May 2 and again on May 5. The top 3 feet of all treated trees browned and none of these trees showed any sign of recovery.

Other tests began in July and all weekly treatments resulted in some plant injury. Further tests of formulations and methods were begun in August.

Figure 26.--Testing for insect toxicity produced in black locust by application of systemics.



Forest Diseases

Research efforts during 1957 were on the oak wilt disease, a major threat to oaks in the United States. At present, the disease staff at Columbia is devoting almost full time to this problem. Although this emphasis on oak wilt is likely to continue for several years at Columbia, the Division will broaden its investigations to include other problems. Two problems now receiving major attention are: Chlorotic dwarf of white pine and a potentially serious canker disease of yellow-poplar. Preliminary studies on the etiological phases of these have just begun.

Mortality in Wilt-Infected Oaks

Oak wilt infection in trees of the red oak group is believed to result almost invariably in death of the diseased tree. Trees of the white oak group are known to be less severely affected but no quantitative measure of mortality rate has been reported. During 1957, 462 oaks in Missouri that were wilt infected during the period 1952-1956 were re-examined. Mortality was as follows:

<u>Species group</u>	<u>Examined</u> (Number)	<u>Dead</u> (Percent)	<u>Living</u>	
			<u>Symptoms present</u> (Percent)	<u>Symptoms absent</u> (Percent)
Black oaks	365	99	1	0
White oaks	97	19	26	55

These results support the accepted concept of a high virulence in the red oak group. They are not conclusive for the white oak group because the disease may reactivate in some symptomless trees, and some of the living trees with symptoms may recover. The results suggest that the mortality rate in wilt-infected white oaks is relatively low.

It is gratifying to find that the threat of the wilt disease to one group of oaks is perhaps less than once supposed. However, these results also emphasize that the oak wilt fungus may persist in white oaks and serve as a reservoir of inoculum.

Oak Wilt in Logs and Lumber

There is concern that oak wilt might be spread through lumber or other products cut from diseased trees. This problem is being studied in Missouri. Blocks containing both sapwood and heartwood of black and white oaks are being exposed to the fungus

under various conditions. The results obtained from this and other studies will provide information on the relative susceptibility of heartwood and sapwood to invasion by the oak wilt fungus.

Oak Wilt Remains Virulent After 10 Years in Culture

Many pathogenic fungi become less virulent when grown for long periods on culture media. In 1957, 5 isolates of the oak wilt fungus were tested for pathogenicity by inoculation into vigorously growing, 6-to-8-year-old trees in a nursery in Missouri. The cultures, originally obtained from naturally infected trees in 1947, 1949, 1950, 1951, and 1952, had grown continuously on standard laboratory media since isolation. Spore suspensions of each of the isolates were used to inoculate 5 red oak and 5 white oak trees. Six weeks after inoculation the fungus was isolated from 29 of the 50 trees tested, 20 red oaks and 9 white oaks.

Final outcome of the tests cannot be determined until the 1958 growing season. However, the early results, particularly for red oaks, indicate little difference in the pathogenicity of the different-aged isolates. Oak wilt fungus isolates apparently retain a very high degree of virulence while growing strictly as saprophytes for periods of at least 10 years.

Root-Grafts in Oaks

The importance of oak wilt fungus spread through root-grafts is unknown. The frequency and pattern of root grafting in oaks are being studied in Missouri. Such information will be valuable for evaluating and controlling underground disease spread. The investigations are exploratory but early results are interesting.

Twenty-five white oaks and 25 black oaks were cut and the stumps treated with a solution of copper sulfate. Symptoms of copper injury in adjacent untreated trees indicated root-grafts. Sixteen percent of the black oaks and 20 percent of the white oaks in the test area were connected. The greatest distance between stems of grafted trees was 36 feet. In one instance, a treated tree was connected to three other trees in a series. No other cases of more than two trees connected by root-grafts were found. There were no grafts between trees of different species.

Techniques for tracing root-grafts with radioactive isotopes were tested. Rubidium⁸⁶ chloride was introduced into the vascular system of oaks and its movement followed with a Geiger counter (fig. 27). No root-grafts were located in the eight trees used in this preliminary work. But, the effectiveness of the application methods indicate numerous uses for this technique in future studies.



Figure 27.--Movement of the isotope into the roots is very rapid. Activity was measured in this root 45 seconds after the active solution was poured into the cone.

Isolations from Acorns Failed to Yield Oak Wilt Fungus

All attempts to recover the oak wilt fungus from acorns of diseased trees have failed. In 1956 it was observed in Missouri that acorns from diseased black oaks germinated readily without the usual period of stratification at low temperatures. Mature acorns collected from healthy oaks of the same species failed to germinate.

Further attempts to isolate the fungus from acorns during 1957 were also unsuccessful even though the fungus could be removed from all parts of branches and twigs including the point of acorn attachment. All of the acorns from diseased trees that were not weevil infested germinated. Sixty-six percent of the immature acorns from healthy trees also germinated.

It appears that the oak wilt fungus does not commonly invade acorns on infected trees and seed transmission of the disease is unlikely. These results also suggest that the germinative response in acorns from diseased trees is probably due to lack of maturation and dormancy, rather than the presence of some stimulant in the diseased tree.

Monthly Inoculation Tests

Several black oaks in Missouri are being inoculated with the oak wilt fungus during each month of the year to find out if periods of non-susceptibility in the tree occur. Although the study is not completed, the results to date fail to reveal any periods of immunity. Some inoculated trees have become infected in each month from March through August and susceptibility seems greatest during May, June, and July.

Propagation of Oaks and Other Hardwoods

In certain forest disease research it is desirable and often essential to work with groups of trees that are genetically identical. One method of getting such material is through vegetative propagation. Methods are being studied for vegetative propagation of hardwoods. Cuttings were obtained in June and July from sprouts or trees up to 6 years old. Prior to planting in vermiculite they were treated with one of several "root hormones" or were left untreated. Intermittent mist (30 seconds on, 90 seconds off) was applied to the cuttings during the daylight hours.

The following species have been successfully rooted: Pin oak, northern pin oak, northern red oak, bur oak, overcup oak, willow oak, saw-toothed oak, Allegheny chinkapin, and yellow-poplar. Rooting success varied from 0 to 90 percent depending on species, source of cuttings, and treatment. The rooting potential of individual trees appears to be the most important factor in vegetative propagation. Differences in rooting success between individuals of the same species have been much greater than the differences between species or treatments. Also, some type of hormone treatment is beneficial but no one chemical is best for all species.

Stem Canker of Yellow-Poplar

An apparently new canker disease has been discovered in southern Ohio. Affected trees exhibit one to many elliptical cankers which "bleed" profusely in the fall months (fig. 28). Infected inner bark becomes moist and brownish-black, then dries, and does not slough-off readily. A greenish discoloration can be found in the sapwood above and below cankered areas.

Isolations made from naturally infected trees have consistently yielded a species of Fusarium, a fungus known mostly for its attacks on food crops. Inoculations to nursery and field trees have shown the organism to be pathogenic, but artificially induced cankers are yet too small to definitely establish that this fungus is the primary causal agent.

Chlorotic Dwarf of Eastern White Pine

Chlorotic dwarf, a disease restricted to eastern white pine, occurs in young plantations throughout eastern United States. Although early stages of the disease are difficult to identify, affected trees are eventually stunted and have short chlorotic needles (fig. 29). Death follows.

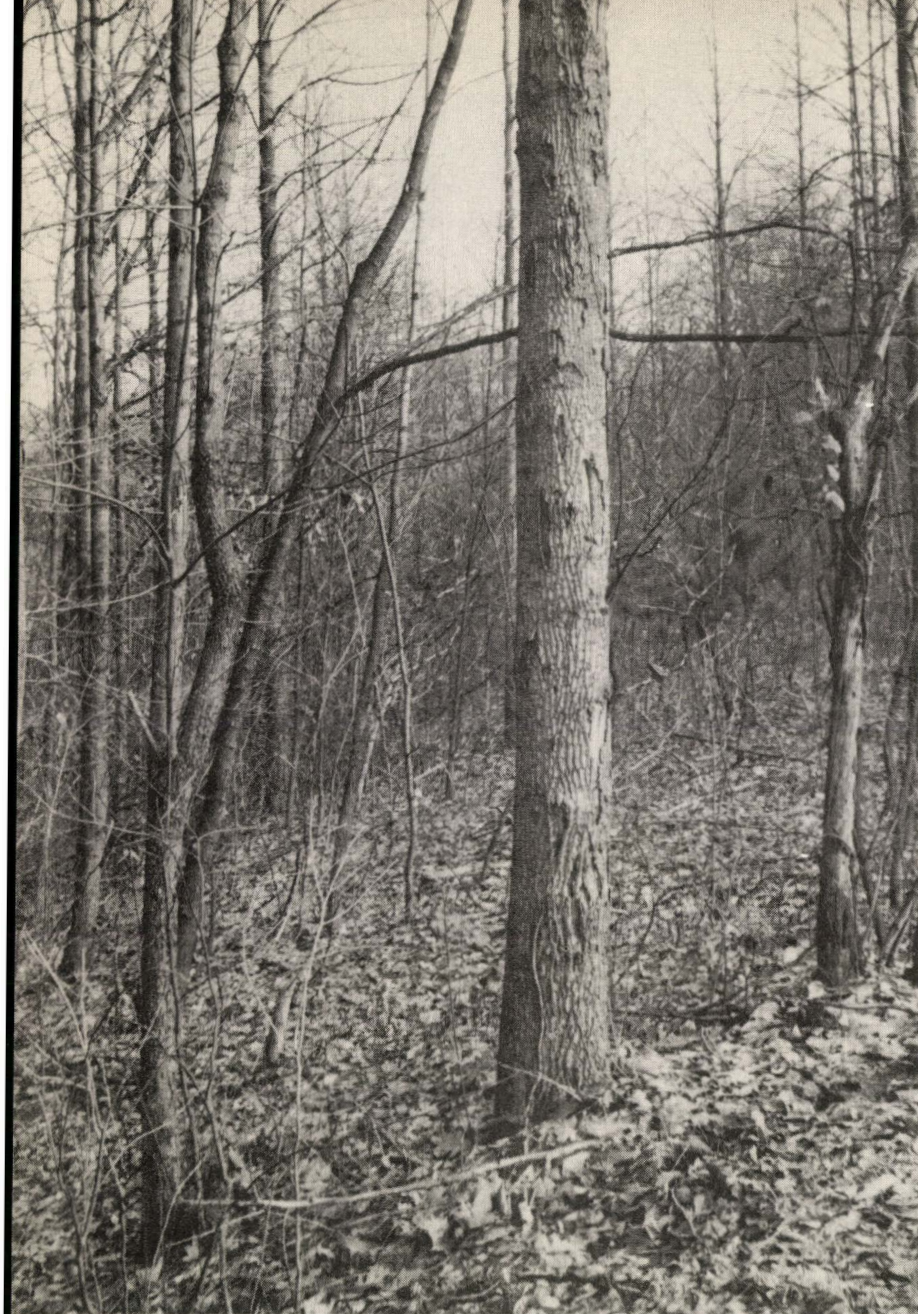


Figure 28.--Infected yellow-poplar in southern Ohio, showing typical cankers.

In 1957, studies were begun to determine the possible significance of nutrition, virus, and genetics. Information obtained from soil and leaf analysis will be correlated with observations made on diseased plantation trees receiving applications of different chelates. In addition, seed collected from healthy trees was planted on different sites to find out what effect environment has. Grafting experiments are in progress to determine possible virus relationships. A nursery is being established to see if inherited characteristics have an effect.

Figure 29.--Chlorotic
dwarf tree (foreground)
is same age as those
in background.
(Ornamental Plants
Section, Agricultural
Research Service)



Root Rot in Thinned Plantations

Root rot of pines caused by Fomes annosus has been found in Missouri for the first time. Severe mortality occurred in a short-leaf pine plantation and the pathogen was cultured from infected trees. This disease usually doesn't appear until at least 3 years after thinning. Many pine stands in the Central States need thinning, so this disease could become very important. Prompt painting of the cut surface of stumps with creosote is suggested as a control measure.

Range Management

Research has shown that grazing in the 25 million acres of hardwood forests east of the Mississippi River damages both land and trees, and seldom pays. But on a large area in the Missouri Ozarks open timber stands will produce some forage. In such stands range cattle can provide some income from land that offers no prospect for immediate income from forestry. For this reason, the Station's forest grazing research is confined to the Missouri Ozarks.

The livestock industry of Missouri is an important part of the economy. In the Ozarks 87 percent of the value of all farm products sold comes from livestock. Two-thirds of all woodland area is grazed, despite the fact that the production of forage is low on such land. Many farmers depend on forage for income but they have not been able to afford the cost of bulldozing and re-seeding. Instead, they have tried to raise more forage by burning and goating. These methods, although low in initial cost, are often costly in loss of site productivity.

There are about 3 million acres of low-grade hardwood timber in the Ozark area for which the best land use is in doubt. Much more information is needed on the possibility of increasing forage production on these sites. Several studies are in progress that will provide some of the answers on how to increase the forage resource and integrate range grazing with other land use.

Forage Production Increased by Controlling Hardwoods

Forage production of K-31 fescue and little bluestem was greatly increased by removing the competition of low-grade hardwoods. Several methods commonly used to increase forage production were tried in a dense stand of poor hardwoods in March 1956. The control of understory and overstory hardwoods with herbicides, and the control of the understory by burning and the overstory by girdling greatly increased the forage production of planted fescue and little bluestem. Burning alone, with no control of the overstory, did not increase forage production. Fertilizer greatly increased growth of fescue, but had little effect on the bluestem (fig. 30).

In another study, herbicides were more effective than fire in killing low-quality hardwoods to increase forage production. The immediate increase in forage where 2,4,5-T was applied greatly exceeded that where fire was used. And even after 6 years the yield was 5 times greater where 2,4,5-T was used (fig. 31). Forage production steadily decreased on the burned area due to sprout

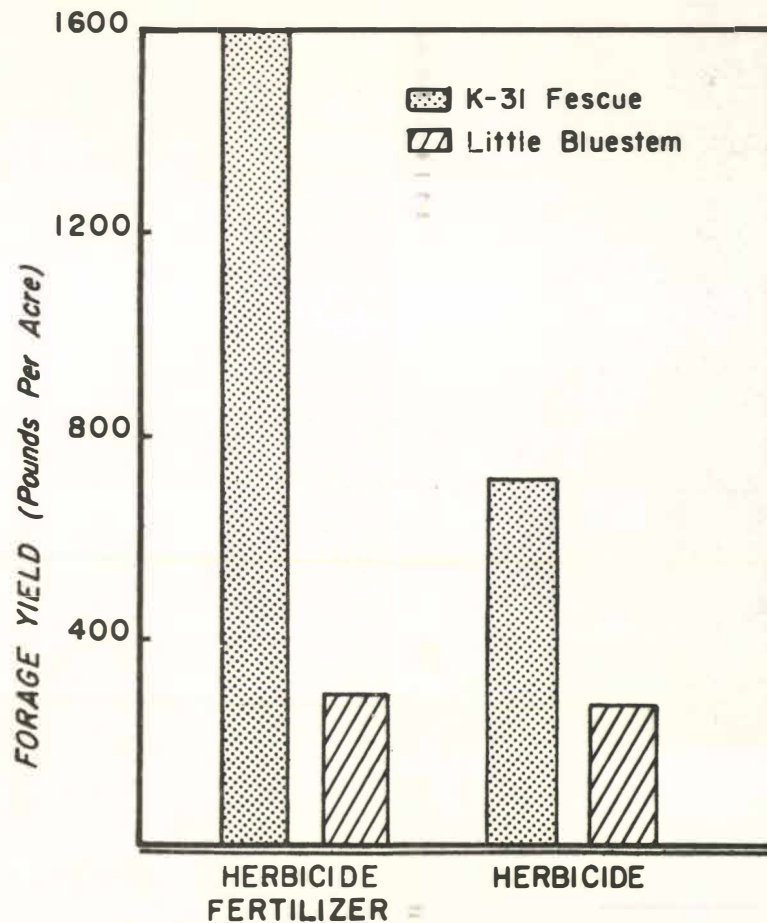


Figure 30.--Forage yields of K-31 fescue and little bluestem in the second season with hardwood control and fertilization.

regrowth and it is now about the same as on the untreated area. The forage on the herbicided area consisted almost entirely of palatable grasses and forbs while on the burned and untreated areas, unpalatable plants made up a large part of the herbaceous vegetation.

Yield in lbs./acre of oven-dry forage 6 years after treatment

	<u>Little bluestem</u>	<u>Other Per. grasses</u>	<u>Legumes</u>	<u>Other forbs</u>	<u>Total</u>
Herbicides	804	174	137	98	1,213
Burn	70	2	167	30	269
Untreated	50	9	126	34	219

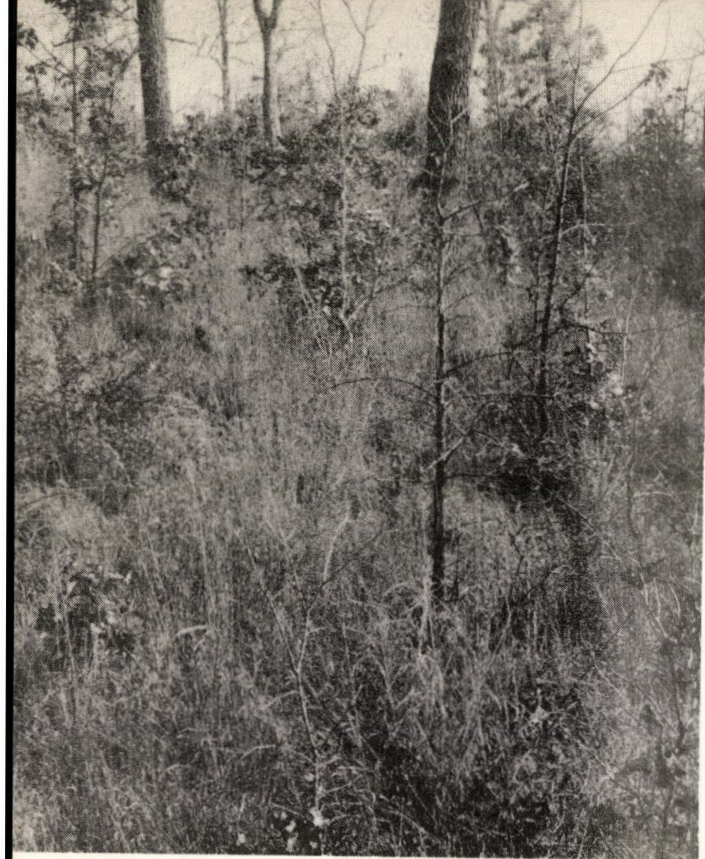


Figure 31.--1957 forage yield was about 1,200 pounds (oven-dry) per acre on this area treated with 2,4,5-T in 1952.

Aerial spraying low-grade hardwood stands with herbicides shows promise as a way to increase forage in Missouri. Before aerial spraying of 2,4,5-T, production was about 50 pounds of oven-dry forage per acre per year (fig. 32). One year after spraying, production had increased 24 times to about 1,200 pounds of forage per acre. The cost of aerial treatment is much less than ground treatment especially on rough terrain and large acreages.

Forage Production is Related to Pine Density

Seven years after a 30-year-old shortleaf stand had been thinned to 50 square feet of basal area per acre, forage production was nearly 450 pounds per acre. Forage production in areas thinned to 70, 90, and 110 square feet of basal area per acre averaged about 80 pounds per acre and the unthinned area had 20 pounds. Understory hardwood were controlled with herbicides. This study shows that only limited amounts of forage are available under well-stocked pine stands. The feasibility of using the forage will depend on the amount and kind produced and on the effects of grazing on tree growth, pine reproduction, and soil compaction. The possibility of using pine land for both forest and range should be more fully investigated.

Key to Important Forage Plants of Ozarks Being Developed

Good progress was made in cooperation with the Botany Department of the University of Missouri in developing a key to help the forest and range manager and the livestock producer recognize 150 of the most important forage plants of the Ozark Region. Scheduled for publication in 1958, this bulletin will also include photographic and taxonomic descriptions as well as ecological and economic information covering distribution, period of growth, and relative forage value at different times in the year.

Forest Wildlife Habitat Management

One of the jobs of the Central States Station is to find better ways to improve the wildlife habitat on National Forest land. A start was made this year in Kentucky in a study of habitat betterment through various harvest systems. This cooperative study with the Kentucky Department of Fish and Wildlife Resources will be located where game is under intensive management on a wildlife management area of the Cumberland National Forest.

Ecology of Glades Studies

The "glade" region of southwest Missouri is the largest area of natural grassland in the State. The 500,000 acres of glades are intermingled with forested areas. Results of a cooperative ecological study with the University of Missouri emphasized the critical balance between prairie and forest in this region. Soil depth and natural cover are correlated with geologic formations. Glade soils are shallow with many horizontal rock outcroppings. Most of the original prairie has been invaded by redcedar and scrub hardwoods. Forest soils are much deeper and support fairly good stands of hardwoods. Indications are that the extensive areas of shallow glade soils are better suited for the production of forage than for timber.

Figure 32.--Forage production under this hardwood stand was about 50-60 pounds (oven-dry) per acre.



Watershed Management

Water supply is rapidly becoming a limiting factor in municipal and industrial growth in the Central States. So the Station's primary goal in watershed management research is to learn how the 43 million acres of forest land in the region can be made to yield the most usable water for the 33 million people. Work is being done in cooperation with universities, states, conservation districts, and other federal agencies in Iowa, Kentucky, Missouri, and Ohio.

Hydrology of Small Watersheds

In cooperation with the School of Forestry, University of Missouri, precipitation and runoff records for three small watersheds located near Rolla, Missouri, are being studied to learn something about the basic relationships between rainfall and streamflow in the Ozarks. The records came from the U. S. Geological Survey and U. S. Weather Bureau, and cover the period October 1, 1948 through September 30, 1955.

The three watersheds differ in size, shape, land use, and cover type. The smallest covers 0.6 square mile with approximately 1/3 in oak forest and 2/3 in grain crops and pasture. The largest covers 14 square miles with approximately 2/3 in oak forest and 1/3 in grain crops and pasture. The soil of the smallest watershed is relatively deep; the soil of the two largest is thin and cherty. During the 7-year period the three areas received an average annual precipitation of 38 inches. Sixty percent of this fell in May through October and 40 percent in November through April. The highest amounts are recorded for May and June, and the lowest amounts for November and December.

Of the total precipitation, 10 inches went into streamflow on the smallest watershed, and 13 inches on the two largest. All three watersheds had similar seasonal distribution of runoff with 30 percent of the annual runoff occurring in July through December, and 70 percent in January through June. The lowest streamflow usually occurred in September and the highest in March. Streamflow generally began to increase in January and to decline in April as the growing season commences. The fact that only 10 of the 38 inches of precipitation ended up as streamflow shows that a big part of total precipitation is "consumed" as evaporation and transpiration.

Of the total runoff, 7 inches occurred during storm periods for all three watersheds. The smallest watershed contributed only 3 inches to streamflow in rainless periods; the two larger watersheds added 6 inches to streamflow in rainless periods. The smallest stream went dry every summer; the two largest streams were never completely dry.

Forest-Soil-Water Relations

One of the objectives at the Station's Athens Forest Research Center is to learn more about hydrologic conditions on ridges of poor site quality for oak and the effects of converting to pine. All tree and woody vegetation was cut on several 1/2-acre blocks in 1953 and these were planted to pine in the spring of 1954. On half of each block sprouts and natural regrowth were permitted to compete with the planted pines and on the balance pine seedlings were released. The first growing season a stand of herbaceous plants, low briars, vines, and seedlings invaded the area providing a rather complete cover for the site. Considering severity of the initial cover treatment within these small blocks there have been no drastic changes in soil erosion, surface water runoff and litter cover during the first 4 years.

During the 4 years the amount of forest floor cover has not changed greatly in the fermentation or humus organic layers (table 8). The litter layer in areas where seedlings are released is some thinner than in the uncut forest. Clear cutting and 4 years regrowth of forest vegetation have not resulted in the forest floor cover decomposing and exposing mineral soil.

Table 8.--Amount of forest floor 4 years after treatment
(Pounds per acre)

Treatment	: Fermen-: : : Litter : tation : Humus : Total			
Uncut control	2,400	7,200	18,000	27,600
Treated, Seedlings Released	1,600	7,800	15,500	24,900
Treated, Seedlings Not Released	2,200	9,900	23,300	35,400

Runoff from the uncut control was small in amount and all storms observed produced runoff of less than 0.01 inch or 2 percent of the storm precipitation. For the treated areas 96 percent of the storms produced negligible runoff and no storm produced more than 0.17 inch. Freezing of soil and litter modified amounts of runoff for only one storm. Under conditions of this study the reserve of forest floor has been adequate to protect the site and changes with time are slow. This suggests that clear cutting, planting, and natural regrowth in small blocks may not adversely affect the soil profile in the control of storm water and the storage of ground water on some ridges in southern Ohio.

Soil Moisture Measurement Techniques Needed for Rocky Soils in Missouri

The actual amount of water stored in a soil and available to plants is greatly influenced by rock content. Standard techniques for measuring soil moisture in rock-free soils are difficult to apply for most Missouri Ozark soils because the rock content may vary from 10 to 90 percent by volume. Very little has been done to devise new techniques to measure soil moisture in rocky soils, which has delayed progress in other lines of research.

A study of the problem is being made in cooperation with the Soils Department of the University of Missouri. To measure bulk density and rock variability in 30 inches of soil over a tight pan (Clarksville stony loam) holes 6 and 12 inches in diameter were compared for sampling. Little difference was noted in bulk density between the larger and smaller sized holes and the 6-inch holes were found to be more efficient.

The rock most commonly found is a hard chert or flint with a low moisture holding capacity. Rock content by weight was found to be quite variable within a 1/10-acre plot. The greatest amount was 10 times more than the least amount in holes of the same size. One hole, 12 inches wide and 30 inches deep contained 147 pounds of rock. Moisture-holding capacity, wilting percentage, and field capacity measurements will be made for various horizons in all holes.

Mine and Oil-Well Pollution in Eastern Kentucky

Soil erosion and water pollution problems are associated with some coal mines and oil wells in eastern Kentucky. Soil, streamflow, and water quality are directly affected. Much of the water from coal mines is highly acid and toxic to plant and animal life (fig. 33). Water from the oil wells usually contains some crude oil and is often very saline. The Berea Center is cooperation with the Cumberland National Forest to devise a method for evaluating the pollution problem. The Berea Ranger District was selected as a sample and 67,500 acres were surveyed. This survey shows that a serious problem exists and research should be started to find corrective measures (table 9).



Figure 33.--Acid water draining from an old drift mine is discharged into a nearby stream.

Table 9.--Number of mines or wells discharging various
amounts of water in 1957, Berea Ranger District

Activity	Water discharge			
	Continuous	Intermittent	None	Total
Drift mine	16	15	5	36
Strip mine	2	7	2	11
Oil well	-	7	6	13
Total	18	29	13	60

1957 Publications

- * Baskett, Thomas S., Dunkeson, Robert L., and Martin, S. Clark
Responses of forage to timber stand improvement in the Missouri Ozarks. Jour. Wildlife Mangt. 21(2): 121-126, illus.
(Forage species used by deer can be increased by timber stand improvement. Five years after cull trees were killed frequency of released grasses and sedges was increased 72 percent, forbs 35 percent, and browse 30 percent.)
- Bretz, T. W. and Buchanan, W. D.
Oak wilt fungus not found in acorns from diseased trees. Plant Dis. Rptr. 41(6): 546.
(The oak wilt fungus was found in approximately half of the twigs taken at random from a tree that was inoculated August 1, 1956 with a suspension of oak wilt spores. However, no fungus was found in 124 acorns even though many of them were taken from twigs that had the fungus.)
- Bretz, T. W. and Jones T. W.
Oak flowers may serve as infection courts for the oak wilt disease. Plant Dis. Rptr. 41(6): 545.
(Describes studies and results that indicate that oak flowers may serve as infection courts for the oak wilt disease.)
- * Brinkman, Kenneth A.
Silvical characteristics of black oak. Misc. Release 19, 14 pp., illus.
(Summary of available information on the silvical characteristics of black oak. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)
- * Brinkman, Kenneth A.
Silvical characteristics of black walnut. Misc. Release 22, 15 pp., illus.
(Summary of available information on the silvical characteristics of black walnut. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

* Available for distribution.

* Buchanan, W. D.

Brentids may be vectors of the oak wilt disease. Plant Dis. Rptr. 41(8): 707.

(The brentid, Arrhenodes minuta (Drury), may be a factor in the spread of oak wilt disease. Tests with this insect in Missouri show that oak wilt developed in 3 of 10 trees exposed to 137 beetles artificially contaminated with the oak wilt fungus.)

Carmean, Willard H.

The structure of forest soils. Ohio Jour. Sci. 57(3): 165-168.

(Forest and agricultural soils are compared to show differences in structure that result from different cultural treatments and vegetal covers. Undisturbed forest soils generally have better structure from the standpoint of water quality and periodicity of water yield from watersheds.)

* Central States Forest Experiment Station

Central States timber resources. Misc. Release 13, 30 pp., illus.

(Forest area and timber volume statistics for the Central States.)

* Central States Forest Experiment Station

Forest Pest Observer. Vol. 1, No. 1, 3 pp.

(First of a series, reporting recently observed forest insect and disease activity through the Central States region.)

* Central States Forest Experiment Station

Hardwoods for pulp. Published by Area Services Division, Southern Illinois University, 28 pp., illus.

(This is a prospectus of the possibilities for obtaining raw materials and establishing wood pulping plants in the southcentral part of the Midwest. The forest resources and other factors affecting pulp mill establishment are discussed.)

* Central States Forest Experiment Station

Norman's informin' again. 1956 Annual Report, 47 pp., illus.

(Brief review of Station's activities for 1956.)

- * Clark, F. Bryan and Liming, Franklin G.
 Low-grade hardwood stands in the Missouri Ozarks respond to stand improvement. Jour. Forestry 55(5): 354-358, illus. (Basal area growth was greatest in the most heavily thinned 40-year-old, low-quality hardwood stand. White and black oak grew faster than blackjack and post oak. Planted shortleaf pine responded vigorously to complete release, generally dominating the hardwood reproduction.)

- * Deitschman, Glenn H. and Herrick, David E.
 Logging injury in Central States upland hardwoods. Jour. Forestry 55(4): 273-277, illus. (Presents results of a study of the effects of skidding method and tractor size and attachments on damage done during logging to residual hardwoods.)

- * Engle, LaMont G. and Williams, Robert D.
 Scarifying seedbed boosts yellow-poplar germination. Sta. Note 110, 2 pp. (Yellow-poplar seed germination was 10 times greater on a scarified seedbed than on the undisturbed forest floor. Average stocking after logging was over 10,000 seedlings per acre.)

- * Finn, Raymond F. and Limstrom, Gustaf A.
 Black locust sprouts also susceptible to borer attacks. Sta. Note 101, 2 pp., illus. (Clear cutting black locust plantations on strip-mined land resulted in better survival and growth of sprouts than did partial cutting, but the sprouts were heavily damaged by the locust borer.)

- * Funk, David T.
 Silvical characteristics of honeylocust. Misc. Release 23, 14 pp., illus. (Summary of available information on the silvical characteristics of honeylocust. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

- * Green, Alan W. and Neebe, David J.
 Early development of yellow-poplar on two planting sites. Sta. Note 106, 2 pp., illus. (Yellow-poplar planted on a recently cleared forest site in southern Illinois were more than 4 times as tall as those planted on a nearby old field after 3 years. There was little difference in survival rates between sites.)

* Greth, John W.

Ax girdling kills large cull hardwoods. Sta. Note 107, 2 pp., illus.

(More than 2,600 trees were ax girdled and 97 percent had dead crowns after 3 years. One-third of the trees sprouted from the stump. The treatment was most effective for the larger sawtimber-sized trees.)

* Herrick, David E. and Jackson, Willard L.

The butt log tells the story. Sta. Note 102, 2 pp.

(A progress report on a study designed to find a practical method for estimating the value of lumber in a standing tree by inspecting only an indicator section of the bole.)

* Hosner, John F. and Minckler, Leon S.

Chemical debarking offers means of utilizing pine thinnings. Jour. Forestry 55(6): 458-460, illus.

(Within a few months after applying sodium arsenite on the girdled stems of pines the trees were dead and the bark was loose enough so that most of it would be removed during logging. The treatment offers promise as a method of thinning and producing bark-free wood.)

Hutchison, O. Keith and Thornton, Phillip L.

Ohio's forest resources. Northeast. Logger 6(4): 20-21, 56-58, illus.

(Describes the forests of Ohio as found in the initial Forest Survey. Includes a discussion of area, types, ownership, volumes, quality, growth, and cut.)

* Krajicek, John E. and Brinkman, Kenneth A.

Crown development: An index of stand density. Sta. Note 108, 2 pp. Also published in Sho-Me Live Wire 9(2): 2.

(Presents a new measure of stand density, the Crown Competition Factor, which is an expression of the crown competition within a stand.)

* Kucera, C. S. and Martin, S. Clark

Vegetation and soil relationships in the glade region of the southwestern Missouri Ozarks. Ecology 38: 285-291, illus.

(The development of the forest and glade types in the southwest Missouri Ozarks is associated with differing geologic formations. Soils in the glades are drouthy and shallow. The residual mantle supporting forest growth has weathered to a greater depth and retains more moisture.)

- * Liming, Franklin G.
Homemade dendrometers. Jour. Forestry 55(8): 575-577, illus.
(Describes how to make and use a simple, homemade dendrometer for accurately measuring changes in tree stem circumference.)

- * Limstrom, G. A.
Silvical characteristics of chinkapin oak. Misc. Release 24, 11 pp., illus.
(Summary of available information on the silvical characteristics of chinkapin oak. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

- * Little, Elbert L., Jr., Brinkman, Kenneth A., and McComb, A. L.
Two natural Iowa hybrid poplars. Forest Sci. 3(3): 253-262, illus.
(Provides botanical descriptions and English names for two natural hybrids of white poplar and bigtooth aspen.)

- * Martin, S. Clark
You can kill post oak saplings in Missouri with Ammate and an ax. Sta. Note 105, 2 pp., illus.
(Application of Ammate to fresh cut stumps greatly reduced sprouting of small post oaks. Crystals were more effective than solutions, but also much more expensive.)

- * Merz, Robert W.
Silvical characteristics of Ohio buckeye. Misc. Release 16, 12 pp., illus.
(Summary of available information on the silvical characteristics of Ohio buckeye. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

- * Merz, Robert W.
Silvical characteristics of shellbark hickory. Misc. Release 18, 14 pp., illus.
(Summary of available information on the silvical characteristics of shellbark hickory. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

- * McCauley, Orris D., and Quigley, Kenneth L.
Markets for Ohio timber. Misc. Release 14, 53 pp., illus.
(Lists buyers of primary forest products in Ohio. Also gives information on specifications and prices.)

* McCoy, E. Wesley

How to minimize the effects of tension wood in cottonwood.
Sta. Note 103, 2 pp., illus.

(Describes how the occurrence of tension wood in cottonwood is related to tree lean and suggests timber management, logging, and milling practices for minimizing both the development and the adverse effects of the abnormal wood fibers.)

* Minckler, Leon S.

Response of pole-sized white oak trees to release. Jour.
Forestry 55(11): 814-815, illus.

(Both "fast" and "slow" growing white oak pole-sized trees were released from overhead shade. All the released trees showed an increase in diameter growth rate, but the fast-growing codominant and intermediate crown class trees responded best.)

* Minckler, Leon S.

Silvical characteristics of pin oak. Misc. Release 20,
10 pp., illus.

(Summary of available information on the silvical characteristics of pin oak. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

Mitchell, Glen H. and Quigley, Kenneth L.

Large market ahead for Ohio Christmas trees. Ohio Farm and
Home Research 42(309): 92.

(Reviews Christmas tree marketing in Ohio.)

* Page, Rufus H. and Herrick, David E.

A guide-line light over the log deck can increase sawmill
profit. Ga. Forestry Comm. Release 14, 2 pp., illus.

(A guide-line light over the log deck of a sawmill can help the sawyer produce higher quality lumber.)

* Parrish, Wayne B., Myser, W. C., and Pool, M. P.

Radio-isotopes--a possible means for finding defects in logs
and trees. Jour. Forestry 55(11): 851-852, illus.

(Describes progress in developing a method for measuring decay in standing trees by use of radio-isotopes.)

* Quigley, Kenneth L. and Yoho, James G.

Marketing timber from Iowa farm woodlands. Iowa State Col.
F-122, 8 pp., illus.

(Describes timber marketing in Iowa. Gives marketing suggestions to woodland owners.)

Quigley, Kenneth L. and McCauley, Orris D.

Ohio's forest industries and markets. Northeast. Logger
6(5): 20-21, 62-64, illus.

(Discusses Ohio's wood-using industries. Considers
future expansion in wood-pulp production and in industries
which re-manufacture low-grade lumber.)

* Sander, Ivan L.

Silvical characteristics of northern red oak. Misc. Release
17, 15 pp., illus.

(Summary of available information on the silvical charac-
teristics of northern red oak. Covers distribution, habitat,
life history, and special characteristics. Bibliography
included.)

* Sander, Ivan L. and Williamson, M. J.

Response of a mixed hardwood stand in eastern Kentucky to a
harvest cutting. Jour. Forestry 55(4): 291-293, illus.

(Net annual growth after partial cutting averaged 185 board-
feet per acre for 32 years. Sugar maple is now the predomi-
nant species in the stand. On sites such as the one studied
the faster growing oaks should be favored over sugar maple.)

* Sander, Ivan L.

Disking increases shortleaf pine reproduction, but... Sta.
Note 111, 2 pp., illus.

(Disking increased the number of shortleaf pine seedlings
but it also increased the number of the faster growing
hardwood sprouts.)

* Thornton, Phillip L.

1955 Pulpwood production in the Central States. Sta. Note
100, 2 pp., illus.

(About 207,000 cords of pulpwood were harvested from Cen-
tral States forests in 1955. Seventy percent of the total
was cut in the forests of Ohio and Illinois.)

* Thornton, Phillip L.

Pulpwood production continues to increase in the Central States.
Sta. Note 104, 2 pp.

(1956 production of 272,100 cords was 31 percent above the
1955 figure. Soft hardwoods made up 52 percent of the total--
pine pulpwood accounted for an additional 10 percent.)

* Thornton, Phillip L.

1956 Charcoal production in the Central States. Sta. Note
109, 2 pp.

(Forty-one plants produced 30,000 tons of bulk charcoal in the
Central States in 1956 and used almost 70 thousand cords of
roundwood and mill residues. More than 70 percent of the pro-
duction came from kilns in Missouri.)

* Thornton, Phillip L.

Veneer-log production in the Central States - 1956. Sta. Note 112, 2 pp.

(About 55 million board-feet of veneer logs were produced in the Central States in 1956: Sixty percent of the volume was in face or commercial veneer logs; the remainder was used in the manufacture of containers.)

* Whitmore, Roy A., Jr., and Jackson, Willard L.

An improved method for estimating quality in standing trees. Jour. Forestry 55(2): 142-143, illus.

(Suggests use of the Forest Products Laboratory log-grading rules for standing trees by basing the grade of each 16-foot log in the standing tree on its best 12 or 14 feet.)

* Whitten, Russell R.

Dutch elm disease control. Misc. Release 12, 16 pp., illus. (Discusses importance, symptoms, and control of Dutch elm disease.)

* Williamson, M. J.

Silvical characteristics of eastern redcedar. Misc. Release 15, 14 pp., illus.

(Summary of available information on the silvical characteristics of eastern redcedar. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

Wray, Robert D.

Federal forest research in Ohio. Northeast. Logger 6(4): 28-29, 64-65, illus.

(Reviews the Station's current forest research work in Ohio.)

COOPERATIVE PUBLICATIONS

Bretz, T. W.

The Allegheny chinkapin and two exotic oaks susceptible to oak wilt. Plant Dis. Rptr. 41(4): 368.

(Lists additional susceptibles to the oak wilt disease on the basis of inoculation tests.)

**Hosner, John F.

Conserving our farm forests. Jour. Soil and Water Cons. 12: 21-25, illus.

(Five major handicaps to increasing the degree of forest conservation are enumerated: Small size of holdings,

** Available from Southern Illinois University.

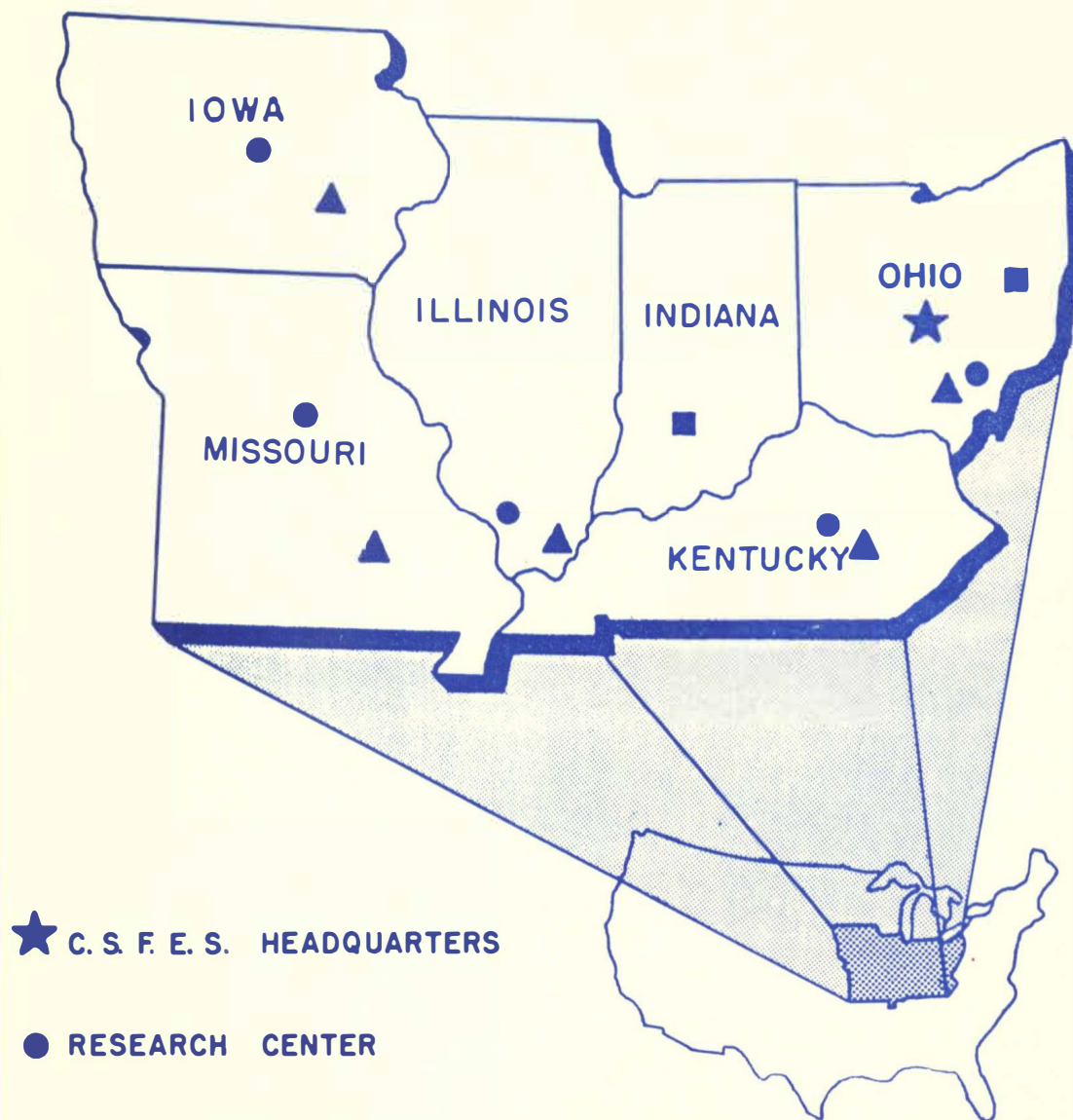
specialization in farming, lack of suitable financing, lack of understanding of woodland values, divided returns--public and personal--from conservation decisions. Five ways to increase forest conservation are also listed and discussed: Increased emphasis on education, encouraging consolidation of farm holdings, research to raise efficiency of operations, increased public assistance where public receives the greatest good, and some form of self regulation.)

****Hosner, John F.**

Effects of water upon the seed germination of bottomland trees. Forest Sci. 3: 67-70.

(The seed of six species of bottomland trees was subjected to soaking in water for periods varying from 4 to 32 days. Although red maple, silver maple, sycamore, and elm seeds failed to germinate while soaking in water, immediately upon removal germination was rapid and consistently high for all periods of time. Submerged cottonwood and willow seeds germinated in 4 days. Apparently flooding of bottomland hardwoods up to periods of 32 days does not greatly effect germination of the six species tested.)

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